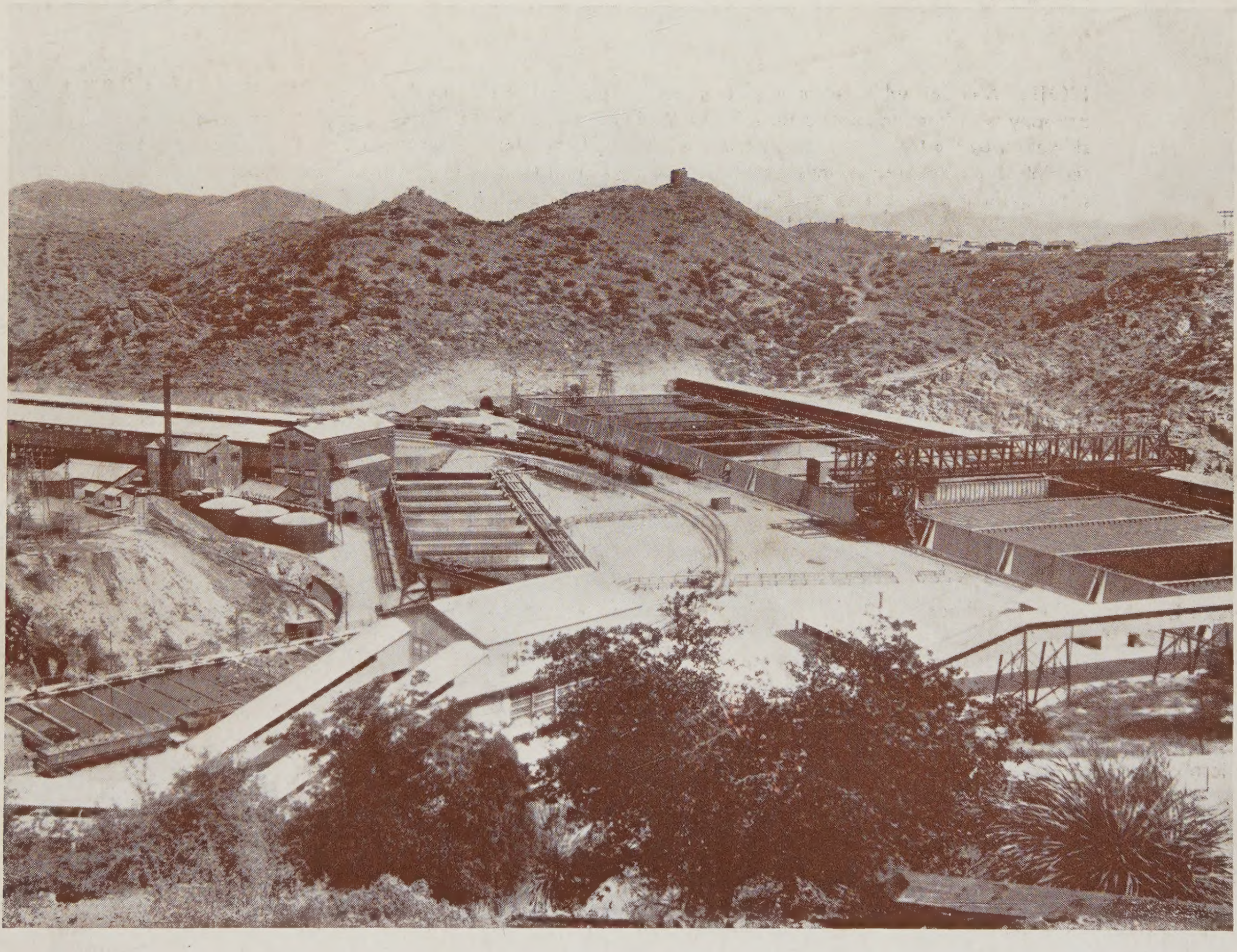
Electrical Engineering

July
1932



Published Monthly by the
American Institute of Electrical Engineers

FUTURE MEETINGS of the AMERICAN INSTITUTE of ELECTRICAL ENGINEERS

Place	Date	Nature	Manuscript Closing Date
Vancouver, B. C.	Aug. 30-Sept. 2, 1932	Pacific Coast Convention	(Closed)
Baltimore, Md.	October 10-13, 1932	District Meeting	July 10, 1932
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	Oct. 23, 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that such papers may be docketed for consideration by the technical program committee, which formulates programs for all meetings several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author important and helpful information explaining the Institute's rules relating to the preparation of manuscript and illustrations.

Future Meetings of Other Technical Organizations

Society and Nature of Meeting	Place	Date	Correspondent
American Gas Association annual convention	Atlantic City, N. J.	Oct. 10	C. W. Berghorn, Secy., Mfgrs. Sec., 420 Lexington Ave., New York, N. Y.
American Physical Society	Chicago, Ill.	Nov. 25–26	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Physical Society	Pasadena, Calif.	Dec. 16–17	L. B. Loeb, Pacific Coast Secy., Univ. of California, Berkeley, Calif.
American Physical Society annual meeting	Atlantic City, N. J.	Dec. 28–30	W. L. Severinghaus, Secy., Columbia Univ., New York, N. Y.
American Society of Civil Engineers, fall meeting	Atlantic City, N. J.	Oct. 5–8	G. T. Seabury, Secy., 29 West 39th St., New York, N. Y.
Camp Cooperation XII Soc. for Electrical Dev.	By Boat to Bermuda	Aug. 3–8	James Smieton, Jr., Secy., 420 Lexington Ave., New York, N. Y.
Empire State Gas and Electric Assn.	Saranac Lake, N. Y.	Sept. 22–23	C. H. B. Chapin, Grand Central Terminal, New York, N. Y.
Illuminating Engineering Society	Swampscott, Mass.	Sept 26–Oct. 1	E. H. Hobbie, 29 W. 39th St., New York, N. Y.
N.E.L.A. Rocky Mountain Div., annual meeting	Estes Park, Colo.	Sept. 12–14	G. E. Lewis, Managing Dir., 366 Gas and Elec. Bldg., Denver, Colo.
National Safety Council annual safety congress	Washington, D. C.	Oct. 3–7	W. J. McCarter, Secy., The Cleveland Railway Co., Cleveland, Ohio.
Pennsylvania Electric Assn.	Bedford Springs, Pa.	Sept. 7–9	H. A. Buch, Telegraph Bldg., Harrisburg, Pa.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

33 West 39th St., New York, N. Y.

Electrical Engineering

Registered U. S. Patent Office

Volume 51 No. 7

The JOURNAL of the A.I.E.E. for July 1932

PUBLICATION OFFICE, 20th and Northampton Streets, Easton, Pa.

EDITORIAL AND ADVERTISING OFFICES, 33 West 39th Street, New York, N. Y.

ENTERED as second class matter at the Post Office, Easton, Pa., April 20, 1932, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

SUBSCRIPTION RATES—$10 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Islands, Central America, South America, Haiti, Spain, and Spanish Colonies; $10.50 to Canada; $11 to all other countries. Single copy $1.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index and Engineering Index.

Printed in the United States of America. Number of copies this issue—

21,500

This Month—

Front Cover

Leaching plant of the Inspiration Consolidated Copper Company at Inspiration, Ariz. This plant has an operating capacity of approximately 80 tons of electrolytic copper per day, with power supplied through 3 5,450-hp. motor-generator sets, having a combined capacity of 36,000 amperes at 320 volts, and a voltage range from 0 to 320.

Photo courtesy Westinghouse Elec. & Mfg. Co. and Inspiration Consolidated Copper Co.

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Officers and Committees (For complete listing see p. 71–76, January 1932 issue of ELECTRICAL ENGINEERING.)

NEW OFFICERS elected recently to serve the Institute for the year 1932–33 were announced at the summer convention. *p. 517*

INDUSTRIAL MANAGEMENT and engineering are twin brothers; they have developed together. So states an authority on engineering education in discussing the educational aspects of engineering and management. *p. 476–481*

BEHAVIOR of the plate and grid currents in a grid-controlled mercury-vapor tube may inhibit the proper functioning of the tube. This is one of the findings of a series of tests on a typical tube of this type. *p. 500–505*

CALORIMETER tests on a large hydro generator show that the stray losses measured under load conditions are practically the same as those measured by the conventional short circuit methods. *p. 497–500*

IMPROVEMENTS in the design of single-phase commutating type railway motors have made it possible to design simpler, lighter, and less expensive a-c. locomotives for the Pennsylvania's New York-Washington electrification than had been used previously on that road. *p. 488–492*

IN THE PAST many of the data for comparable porcelain insulators for use on electric power transmission lines seemed conflicting. A closer agreement among the different manufacturers is indicated, however, in a group of three articles covering recent studies conducted in this highly important field. *p. 505–516*

TO CALL the 1932 A.I.E.E. summer convention just concluded in Cleveland, Ohio, an unqualified success is no mistake. The technical sessions were maintained at their usual high standard; the sports events, always important parts of the summer convention, were "top notchers" as usual; many matters of importance to the Institute were considered at both the annual meeting, and the conference of officers, delegates, and members. *p. 520–523*

C. E. SKINNER whose term as president of the A.I.E.E. expires July 31, 1932, outlined some of the difficulties facing the Institute and electrical engineers in general today, in his summer convention address at Cleveland. Speaking of present economic conditions President Skinner said "...there seems to be a widespread feeling that relief must come through the application of the engineering method." *p. 472–476*

PAPERS presented at the District meeting held May 4–7, in Providence, R. I., elicited the usual amount of discussion. Papers dealing with induction motors were especially well discussed. *p. 524–525*

THOSE who will spend their vacation attending the 1932 Pacific Coast convention to be held in Vancouver, B. C., August 30 to September 2, will find that the committees have spared no effort to make their visits both highly profitable and extremely enjoyable. *p. 518–519*

MEMBERS of the Institute and subscribers continue to make use of ELECTRICAL ENGINEERING'S open forum, the "Letters to the Editor" columns. Discussions of a variety of topics may be found in this issue. *p. 527*

BREAKAGE of conductors on electric power transmission lines formerly attributed to crystallization of the conductor material now is charged to mechanical vibration. The first of two articles dealing with this problem describes laboratory tests made for the purpose of studying the nature of this phenomena, and means of combating it. *p. 482–487*

TELETYPEWRITER communication is used to a large extent in collecting and disseminating meteorological data along with principal airways of the United States. This service, of which a large portion is provided by the government, is used also for plane dispatching and other matters incidental to the operation of the country's airways. *p. 492–496*

The Engineer in a Changing Society

An outstanding article is presented herewith. It is the address given on June 21, 1932, by Doctor Wickenden during a special session of the recently completed forty-eighth annual summer convention of the Institute in Cleveland, Ohio. Its message is of tremendous importance to engineers and to society. ——Editors.

By
WILLIAM E. WICKENDEN President, Case School of Applied Science, Cleveland, Ohio
MEMBER A.I.E.E.

IN THE DRAMA of civilization, the engineer suddenly finds himself called from manipulating the properties in the back-scene and the wings to play a leading rôle in the center of the stage, and the public is not yet sure whether he is the hero or the villain of the piece. The old-line actors who have been thrust into secondary rôles are saying contemptuous things. "This newcomer—he is a mere upstart, with no traditions; he is a hard-minded fellow, without refined sensibilities; he reduces everything he touches to hard and fast quantities, as if the problems of life could be solved on a slide-rule and an adding machine; he cares nothing for beauty and serenity; he fills our cities with noise and ugliness and the countryside with grime and waste; he standardizes all that he touches; he makes robots out of men by day, and fondly imagines that he can turn them back into men after working hours by giving them bathtubs, radios, and cheap automobiles. This fellow is a philistine, with no love for the human spirit."

It is hard to cast the engineer of today into the mold of a hero. No modern Virgil has quite dared to begin an epic "Tools and the man I sing," but then Aeneas had plenty of time to become a legendary figure before Virgil took him in hand. Just at the moment heroes are out of fashion, anyway. The echoes of the greatest war in history are barely stilled, and not one military idol has a pedestal. Foch retires in simple dignity to write his memoirs; Hindenburg hangs up his saber and goes to work for the Fatherland; and Pershing remains the best tailored general in retirement. Shades of Wellington and U. S. Grant! Heroes are out of fashion.

Some of our contemporaries, wearied by the shocks of revolution and transition, are feeling homesick for the middle ages. They would like to see us back in the thirteenth century again, building Gothic cathedrals for the sheer joy of faith and love of beauty. That was the day for heroes, only then men called them saints. Seen from afar, what a simple and unified life that was, with no cross-purposes, no complexes, and no frustrations. Human life and society had but one aim, one ideal, one value, one goal, and that the life beyond. The attainment of sainthood, if not in this world at least in the next, was the goal of all striving. All work was religious work and every calling had its patron saint. Many of the saints seem to have won their halos by reputed services in making crops to flourish, in driving away pests or in warding off epidemics. Perhaps our scientists and inventors are 6 centuries too late. Pasteur, Lister, Edison, and Marconi would most certainly have been canonized, and perhaps even a special day set in the calendar for the veneration of Saint Henry Ford.

Geniuses, it would seem, have been growing either more rare or more commonplace under the blighting touch of science. Who in these 3 centuries since Galileo dares to measure his stature with a Moses, a Homer, an Alexander, a Plato, a Jesus, a Michael Angelo, or a Shakespeare? The essence of modernity is that progress no longer waits on genius; instead we have learned to put our faith in the processes of research and the organized cooperation of ordinary men. To the ancients the pursuit of knowledge was like placer mining—a pursuit for solitary prospectors. Nuggets of truth were found occasionally, and sometimes in a fairly pure state. It would seem that these nuggets were more often hoarded than milled into the coinage of common knowledge. Very often the nuggets were lost or forgotten, waiting a thousand years to be rediscovered. Three centuries before Christ, Aristarchus undertook to measure the distances separating the earth from the moon and the sun, and posited the earth's revolution about the latter. Shortly after an Alexandrian Greek, Eratosthenes, proved the earth to be a sphere and actually measured its diameter within a scant 50 miles of error. Yet none of this knowledge availed to keep Galileo from threat of torture and excommunication.

Science Becomes Powerful

Man began to subdue nature and to transform his world when—about 3 centuries ago—he began to mine the hidden veins of knowledge systematically, when he learned not only to recognize truth in its free state, but to separate the finely dispersed gold from the baser ore of common experience, by measurement, by experiment, by hypothesis, and by verification.

Science became powerful when it became cumulative, when observers began to keep detailed records, to publish their findings to the world, to organize co-operating groups in order to pool and criticize their experiences. Science became powerful when its gold was no longer hoarded but was coined into everyday knowledge and use.

Science a Division of Knowledge

Science, too, owes much to the principle of division of labor. Francis Bacon, who by profession was Lord Chancellor of England, was able to claim all knowledge as his sphere in the sixteenth century. Effective science began when it passed from the occasional amateur into the hands of men who made the winning of knowledge their special function or profession. At once these men began to break knowledge up into smaller and smaller fragments, in order to pursue it more intensively. Recently ex-Senator Pepper, of our neighboring state of Pennsylvania, made this contrast between the specialism of science and the generalism of philosophy the subject of a clever epigram. Scientists, he observes, are men who learn more and more about less and less till they end by knowing everything about nothing; while philosophers learn less and less about more and more until they know nothing about everything. In any well-balanced educational program science needs the compensating values of philosophy and art, because of this fragmentizing of nature and experience.

Group Effort, Not Individual, Becomes Important

As science has become more dominant in human activity, the reign of genius has begun to fade. Though rich in great names, the annals of science are strikingly devoid of towering figures. Science grows by accumulation rather than by brilliant and unpredictable strokes of genius. Its victories belong to the army of patient investigators in sequestered laboratories, rather than to some rare Napoleon of the lecture platform. Its ideal is that of removing the hazards of chance from progress. The key to the technological revolution of the last century is not in individual wizardry, nor in genius appearing suddenly like a prophet from the wilderness; it is to be found in the capacity which men have developed to work in organized groups, developing their leadership from within.

It is this ideal of progress through cumulative effort rather than through genius—progress by organized effort, progress which does not wait for some brilliant stroke, some lucky discovery, or the advent of some superman, which marks the chief contribution of science to social philosophy. The results are brilliant, but they fail to satisfy the instinct of hero-worship. "Arms and the man I sing," chants Virgil in heroic meters to celebrate an age gorgeous in color and romance. The machine age leaves the poet mute, or if he does attempt a song it is in a minor key like Masefield's "Life's a long headache in a noisy street."

Science Is New, Man Is Old

Much of our confusion about the social values of science and its technical uses appears to arise from the fact that our instincts and our circumstances have gotten several centuries out of step. We have a million years of pre-civilized experience imbedded in our nervous systems and our emotions, an experience dominated by fear, cold, want, disease, and hunger. Science and a scheme of life based on organized knowledge are new, startlingly new in terms of race experience. This whole idea of purposed and controlled progress is even newer, and as for getting machines to do work instead of muscles, so that all men may have an abundance, it is an innovation of the moment. For the sake of vividness, let us reduce the scale of race history to terms of individual experience. Instead of a million years of race development, let us think in terms of the time it takes an individual to reach the full maturity of his powers—say 50 years. On this scale how old are civilization, organized science, the idea of progress by deliberate innovation, and this machine age? It is as if *homo sapiens* had settled down from a nomadic existence to tend flocks and till the soil only 19 days ago, as if he had grown curious about the ways of nature a little after midnight this morning, had hit upon the idea that progress does not merely happen but can be deliberately speeded up by invention and innovation about dawn and had gone about the task of making machines do his work for him only as he got up from this morning's breakfast table. Little wonder that his instincts and emotions are in confusion.

A certain anthropologist has in his collection 2 primitive stone implements, which he estimates to differ in age by half a million years. One is crude in the extreme and scarcely recognizable as a tool; the other is fashioned with considerable art. They represent the pace of unaided evolution in human affairs. As an experiment, he took modern boys with no experience in chipping stone and with only the most primitive materials, taught them in a little more than 2 hours to chip out implements superior to the best work of prehistoric man. So much for the pace of progress by deliberate scientific control. Implicit in this episode is the startling contrast between the ancient idea of static society, the mediaeval idea of progress by unaided evolution, and the modern idea of purposed and controlled progress.

Progress Is a New Idea

The very idea of human progress seems to have been alien to the ancient mind. Society, it was thought, lived in repeated cycles. Some genius would appear and lift life for a time to a higher level, but as he became a legendary figure, life would lapse again to its old commonplace. Rise and fall, ebb and flow, were supposed to be inherent in human experience, but the base line was fixed and unchanging. Ancient civilization was largely backward-looking. Its poets sang of some golden age, when men were as gods. Its hopes were centered in some Messiah who

might restore the glories that had been lost. The mediaeval mind, it would seem, was a little more inclined to believe in progress. Mankind might be on the upward grade, but at best it was an almost imperceptible slope, and what was gained could come only by a toilsome process of trial and error. Only modern man, armed with the tools of science, has dared to believe that the welfare of human society was in his own control.

Abundance, Too, Is New

To modern science, and its ideal of cumulative progress, we must also credit the growth among men of a psychology of abundance. To the primitive mind, with the hardships of continuous want and occasional famine branded on its memory, the notion that the earth could be made to yield an abundance of goods for all her children could seem only fantastic. Stoicism represented the highest level of virtue in an age of want. Charles A. Beard speaks of his vivid first impression of the Hindu religion, as the natural expression of the philosophy of a people with no hope in this or any other world of having a square meal. If scanty resources and production forbid the satisfaction of the most elemental of all desires—the longing for food—what greater boon could man crave than emancipation for all consciousness and desire?

The ancient world looked on slavery and aristocracy as natural institutions, or even as ordained of God. They were the inevitable consequences of meager resources. To me, it has always seemed no mere coincidence that the growth of democratic ideals and institutions has moved step by step with the growth of pure and applied science. Democracy is the political and social affirmation of the credo of progress; it rests on faith in man's capacity to produce an abundance for all. Do not make the mistake of blaming today's hunger and want on men of science and on engineers. The sad dilemma of a hungry world in which farmers burn the crops for fuel, of ragged men in the shadow of mills able to turn out 3 times as many garments and shoes as the people have ever used, of a business world as much troubled with unemployed dollars as with unemployed men, all suggests that researchers and engineers have eagerly accepted the psychology of abundance, while the world of finance and of trade is still largely dominated by the economics—or perhaps better the instincts—of scarcity.

Man Overcomes His Limitations

Thomas Carlyle, who had a great deal to say of heroes and hero worship once spoke of man as "the tool-using animal." However Carlyle may have meant it, this is really a great tribute to man's dignity and worth. Man, alone in all nature, overcomes his own limitations. His voice is weak and can carry only a few hundred feet; but he builds an amplifier which can be heard for 5 miles, so that he may speak to possible millions. His hearing is faint, but he makes an electric ear which can detect an airplane 10 miles away. He can count about 10 to a second, but he makes an electric eye fast enough to count 50,000 times a second. If he is accurate, he can estimate lengths to a quarter of an inch, but he captures a light wave and makes it measure to a millionth of an inch. He can see 10 or 20 miles, with the light gathered by his eye, but he makes a telescope which gathers light from galaxies 100,000 light-years distant. He holds up his hand and feels no heat from the stars, but he builds a radiometer, so delicate that in comparison with the current of an ordinary electric lamp, what it detects is equivalent to a change of 2 drops a year in the torrent of a Niagara. He, himself, is a weak, inefficient machine, but he builds on one shaft a machine to supply more work than could be done by all the slaves Lincoln freed.

Only man, in all nature, overcomes his own limitations and explores the universe about him. That is what all tools are for, to overcome the limitations of men. If ever the tables are turned and machines become masters of men, civilization will be upside down. It would be folly to assert that only good can come out of discovery and invention; but it is equal folly to blame upon researchers and inventors the hardships which come as an incidental result of their work. Back of all the details of industrial economy lies half concealed a more profound issue of social utility which scientists and engineers have never directly faced. How far is it humanly profitable to push discovery and invention? Perhaps it would be more appropriate to ask "how fast" in place of "how far." Free play to the social consequences has always been taken for granted. Individuals were bound to suffer hardships but it was assumed that society at large profited immensely. The doctrine of *laissez-faire* assumes that at least a working balance will be kept between technical and moral progress. We have seen industrial technique advance with amazing swiftness, while the moral and legal controls on which the safety of society depends were being readjusted by the fumbling process of trial and error.

Scientific Knowledge Exceeds Social Intelligence

The tools of industry are in themselves neither good nor evil. Good or evil can come only out of the uses to which they are put, and this issue, in turn, depends on the values they are employed to create. We live in a day when the ruling scale of social values has gotten badly out of step with economic facts. The triumphs of physical science and our faith in the social gains from technology have made us overconfident. Have we not built up a social structure far beyond the limits of our social intelligence? The foundations, the materials and the members of this structure which were ample in a simpler day have proved unequal to the complex stresses of a technological era. Our knowledge of men and of social institutions stands today where our knowledge of material nature stood 2 centuries back. There are signs now that we may be compelled to retrace our steps for a time to a simpler social order in order to prepare for an advance movement to new and more secure ground. Civilization may not collapse, but evolution is being speeded far beyond its normal pace. A decade may see changes in the social order suddenly

realized, which are in reality the cumulative result of the work of a century. The educator and the engineer both work with an eye to the future and must take the risks of forecasting on the basis of today's facts and of yesterday's experience.

Responsibility of Engineers Increases

It is plain to all that the focus of our social interests is no longer political, as it was with the revolutionary fathers; it is economic. Their passion for political rights awakens only a hollow echo in the citizenry of today. Government based on geographical representation is showing signs of bankruptcy in an age when men's vital interests divide according to their work, rather than their place of dwelling. Our parties offer us no principles; our elections are fought around persons rather than policies. Actually the farm bloc, the manufacturers' lobby and the bonus seekers stand nearer the real issues of our public life than do the Republican and the Democratic parties. Democracy, with its trust in the collective wisdom of common men, may prove to be unequal to severe social and economic stresses. Russia and Italy have repudiated it; Japan is turning away from it; and Germany hangs precariously in the balance. The engineer has never been a major force in politics; his interests have been administrative, rather than legislative. If, in the turn of evolution, government is to be recast on functional lines of representation, our profession may find its public responsibility greatly increased.

Importance of Agriculture

American agriculture appears to have reached a maximum phase of development and to have entered upon a phase of decline. Until the turn of the century its history was written in terms of an unparalleled expansion of acreage and of markets. We spent millions on research to make the farmer prosperous by increasing his producing power, only to bring him face to face with a blind wall of market limitations. In a period when our manufactured output per capita was doubling and mineral production increasing two and a quarter fold, our farm production per capita fell off appreciably. Farm population has been declining at the rate of a million or more a decade, until the present crisis, and there is now a threat that the mechanization of agriculture will further speed this decline. Hope of reversing this trend seems to be in 2 possible directions. One is a great increase in the use of agricultural products and by-products as raw materials in industry; the other is a return to a self-contained farm life with little dependence on money crops. We may see the story of cotton seed repeated on a vast scale. In 1860 it was garbage, in 1870 fertilizer, in 1880 cattle feed, and in 1890 table food. Today it is an industry representing a turnover of half a billion dollars a year, 40 per cent of which goes to the farmer for what was once a waste and a nuisance. Subsistence farming appears unpromising in itself, but highly promising as an adjunct to industrial employment. The slogan of tomorrow may not be "Back to the soil;" it is more likely to be "One foot in industry and one on the land." If technological and market changes continue to make jobs in industry more and more precarious, some such combination of soil and job is about all that stands between America and a fast-growing proletariat.

While purely rural living is declining, the overcrowding of our cities may also decline. Glenn Frank reminds us that in an age of steam power, it was necessary to bring the worker to the power, but in an age of electrical power we take the power to the worker. Transport by water and rail was inflexible. Town and factory had to come to the traffic arteries. Highway transport, on the contrary, seeks out the remotest hamlets.

Manpower Versus Natural Resources and Machines

Recent advances in technology have definitely ended our traditional shortage of manpower. This may prove to be a wholly new phase in our national history. If so, the social doctrine which has dominated our politics, our education, and our industry, based on the premises that men are scarce while space and materials are abundant, that society must cherish each individual and develop his powers to the full, that industry must adopt every expedient to "save" labor but could afford to be prodigal with ore, coal, oil, timber, water, soil, and other bounties of nature, may undergo radical revision. The incentives which urged on much of our research, have shaped the objectives of invention, and have led us to the unparalleled development of the automatic machine and process in the last 3 decades may lose much of their force. Labor surplus, due to mechanical productivity, may swing America nearer to a parallel with western Europe, with its overcrowding of population and shortage of raw materials.

For a time the curve of industrial progress appeared to be an expanding spiral. Invention, stimulated by labor shortage and drawing on a vast reserve of scientific knowledge, gave us better machines; machines lowered costs, made improved products possible and thus opened up vast new markets; increased turnover provided new capital and credit for plant expansion; capital in turn subsidized research and stimulated invention; workers were displaced by machines, then reabsorbed into new forms of production and service; tasks became more specialized and craftsmanship declined, wiping out the worker's capital in his skill; the buying power of a day's work rose and created new levels of consumption; advertisers and salesmen stood by with stimulation in hand to revive a flagging market; and the cycle was expected to repeat itself indefinitely on an ever-widening scale.

It now appears that once the magic curve is broken, it is extremely difficult to reestablish it. Possibly the curve is not a spiral after all. Some of the factors may have been transients rather than constants, and the curve may have an inherent saturation range where machine economy passes into an area of diminishing returns. Technological unemployment may prove to be not only a temporary hardship to individuals, but also a cumulative process which

brings a menacing train of sociological consequences in its wake. What of the mass markets on which mass production depends? What political consequences may come from the rise of a proletariat with no stake in land or in skill or in permanent employment? What if educational and welfare agencies must make their programs and budgets fit a condition where there will be little employment for the youths under 18 and only posts of leadership for adults over 50? Society may with sound justice insist that the economic burden of labor displacements be reckoned in the costs of production. Engineers contemplating the adoption of labor-saving machinery may have to include some form of social indemnity as part of the cost burden on which a profit may be shown.

Materials Increase in Importance

The moving force in the industrial revolution of the last century and a half has been the substitution of machines for muscular labor. While this force is far from exhausted, it appears to have entered a realm of diminishing returns. Thus far the substitution of artificial materials for those more or less directly obtained from nature has been a distinctly secondary factor, but one which lately has begun to assume a commanding importance. If pushed to its limits, however, this newer force can scarcely be expected to give to industry as a whole as great a stimulus as that which comes from mechanical invention, or from steam and electrical power. It may suffice, however, to afford a considerable check on any slowing down process. In any case chemistry and metallurgy are fairly certain to assume greatly increased importance in every realm of engineering.

As a result of this growing interest in synthetic materials, the deadliest competition of today is not so much between concerns as between products. Research has been made to serve industry as a weapon of attack and of defense. Large concerns which can distribute their risks over a wide range of products and which can afford heavy expenditures for research, appear to have the best prospect of survival. The entrance of industry into the field of research marks the triumph of a new technique of invention. The philosopher Whitehead points out that what was new and peculiar to the nineteenth century was its technology. The art of writing he regards as a greater invention than the steam engine, but one which required a thousand years against a hundred for the engine.

As a matter of fact much of the earlier history of invention is one of crude practical innovation, followed—and often at long intervals—by the refinements of scientific research. Of late we have begun to reverse the order and to close the gap of time. In the modern industrial laboratory this time lag is tending to disappear entirely. Today's research becomes tomorrow's invention and the day after tomorrow's merchandise. Three decades ago industry had a veritable mountain of unused scientific information at its service. Today that margin has largely disappeared. If invention is to give industry another such impetus in the next 3 decades our research efforts must be redoubled.

Conditions May Become More Stable

An era of stable rather than increasing population appears to be at hand. In the early decades of the last century our population was growing at 4 times the world rate, and in the late decades at double. The prospective scarcity of land and natural resources was heavily capitalized and vast fortunes were accumulated from this almost effortless wealth. The tempo of agriculture and industry was adjusted to rapidly expanding markets and rising wealth. Just when this growth began to slacken, the world war gave production an immense but temporary impetus, which has complicated the process of readjustment. The shortage of land and natural resources has failed to arrive; both show signs of having been heavily overcapitalized. The economic life of America is apparently becoming more nearly parallel to that of Europe where the turnover of trade rather than the unearned increment is the chief source of accumulation. The effect of this change on our national habits of philanthropy is an interesting subject for speculation. Will our educational and welfare institutions continue to enjoy private bounties on the scale of the past? Possibly not.

Problems of Youth Increase

To the educator the changes in the age distribution of a population which is in process of becoming stable are even more significant. If we go back to 1850 we find more than half the population of the United States under 20 years of age, and barely one person in 11 a mature adult over 50. The actuarial prospect for 1950, when the curve has flattened out, is that about a third will be under 20 and fully one-quarter over 50, in short that the ratio of mature adults to young people will have increased 4-fold in a century. In 1850, youth was abundant and at a discount, maturity was scarce and commanded a premium. Maturity is now becoming abundant and youth more scarce, with a reversal of the scale of values. The social consequences are evident on all sides. Leisure is being transferred from youth to maturity. The decade from 20 to 30 is becoming less available for adventure and experimentation. Settling down at 30 is beginning to involve risks of never making permanent connections at all. The age level of life's most severe competitions is coming down. More and more, the long and costly sequence of school, college, professional training, and apprenticeship running into the late twenties is being called into question.

If stable population and surplus manpower affect America as they have already affected Europe we may see social strata becoming more permanent, the carry-over of wealth from one generation to another assuming greater importance, a sharper cleavage forming between education for citizenship in general and that for highly intellectual pursuits, greater concern to fit young people efficiently into the economic system, more of education transferred to a continuation period running parallel to early employment, and more of an effort to create and diffuse a national culture concentrated on the growing leisure of middle and late adulthood. These changes seem to the

writer to confirm the wisdom of an educational program which brings the great body of our young engineers into the normal relationships of the industrial world at the age of 22; they also emphasize the need to provide much more generously than in the past for continuation education for graduates.

Secondary Education

The scope of secondary education is being greatly extended and its functions widened. Up to the present the high school has taken only an incidental part in the occupational sorting and guiding of youth. In the early future it may have to carry the major part of this responsibility. The states have been steadily advancing the age limits of compulsory school attendance. Meanwhile commerce and industry have had less and less to offer young persons seeking employment under the age of 18. The highly subdivided tasks open to these untrained beginners usually have little training and exploratory value to those in search of careers. The school has no choice but to hold all its pupils through the early stage of adolescence, and to provide them with the means of finding out their occupational interests and of measuring their capacities against the world's work. The surface of this problem has scarcely been scratched. The number of recognized vocations is said to exceed 30,000 and a majority of those in industry, at least, are so far removed from the elemental experiences of youth that a young person cannot easily visualize them or by imagination project himself into them.

The overwhelming magnitude of this task of social and occupational adjustment, involving each year an army of $2^1/_4$ million recruits to the active duties of life, has threatened to overshadow the intellectual functions of the secondary schools, and to dilute the education of young people of intellectual tastes and gifts. Schools, at times, have seemed to resemble department stores where all kinds of merchandise are considered equally important and the customer is always right. Within the last decade, however, this equalitarian movement has apparently reached its limit.

The engineering profession has much to gain from a clearer separation of the intellectual side of secondary education from its work of social adjustment. For its own recruitment it wishes students who are soundly grounded in the exact sciences, languages, history, and civics, and are accustomed to the rigors of solid intellectual work. If, as, and when the program of work now contemplated for the junior college can be consolidated with the present secondary course and completed by students of intellectual tastes and gifts at the age of 18 or 19, the engineering colleges will readily accommodate themselves to a more advanced level of entrance, and a higher degree of student selection in advance.

The certain result of greater segregation of the intellectual phase of secondary education and its gradual extension will be a greater emphasis on the exploratory and vocational phases for the vast majority together with a rising demand for continuative technical training leading up to the more practical pursuits in business and industry. There is apparently no need to increase the number of engineering colleges, but rather to make their standards more exacting and their professional aims more pronounced. As a complement to these colleges, there is unmistakable need for technical institutes and continuation schools in large numbers, with flexible levels of admission and with programs of work closely related to particular industries and occupations.

New Problems for Capitalism

To return for a moment to broader social movements, we may observe that democratic capitalism, with its strong individualistic ideals, is being challenged by its own economic dilemmas from within and by rival systems in actual operation from without. Capitalism rests on the principle that what matters most to society is the use a man puts his money to after he has acquired it. It assumes that the next generation will need to consume more than the present one, and that whatever surplus of wealth exists can best be entrusted to persons who will not consume it, but use it to augment the means of production. For this service incentives are offered and rewards paid. In an era when both the population and the standard of living were rising rapidly and especially in the pioneer life of a virgin continent, this principle has been socially fruitful through its stimulus to individual initiative and thrift. We may now be at a turning point. Examples of a socially wasteful unbalance between producing and consuming power have multiplied in the post-war period in agriculture, mineral production, and manufacturing alike. Machine technology, with its seemingly limitless capacity for increasing production, has apparently accentuated this loss of equilibrium. The result has been called a dilemma of thrift. The capital and credit structure built up on producing capacity may prove to be larger than the buying power of society can sustain in the presence of forces which tend to diminish the volume of employment available. If so, capital may find it difficult to obtain new outlets and industry may be forced to distribute a larger proportion of its income in forms that directly augment consumption, that is, as wages and cash dividends. Society may deem it expedient to limit the plowing back of profits to increase plant capacity. It may also find ways to limit the mechanizing of production, rather than to have an unemployable proletariat growing on its hands.

Engineers Will Need Social Orientation

Engineers, on whose analysis and judgment hang the risks of future investments and plant extensions, will have new social forces with which to reckon. These new forces will influence not only their more philosophic reflections, but also the arithmetic of engineering economy as well. The current social changes point inevitably to an increasing degree of social control in economic processes. The day is probably past when society will wink at socially wasteful processes of making money, if only it is invested prudently after it is made. The issue is not so much one between capitalism and socialism as

between society and the individual, between a controlled economy and one based on *laissez-faire*. The engineer of a generation hence will not only have a wider range of scientific tools at his disposal, but he will almost certainly be guided by economic premises in which broader conceptions of social expediency will prevail than in the more individualistic past. He may not be an employee of the state, but he will work under a wider range of public regulation.

The engineer of tomorrow will be, as he is today, a social pragmatist, one who accepts the existing order provisionally and works within it, whether it be *laissez-faire* capitalism, Marxian communism, or Italian fascism. He will accept any system, as far as it works. This attitude is fairly inherent in his professional function and duty. If, however, the engineer of tomorrow aspires to be a molding force within the industrial system, he will need a more profound and more critical understanding of economic forces and of social values than that which sufficed for an era of rugged individualism. Social orientation bids fair to rank equally with scientific discipline as an essential basis of his training.

Civilization Must Go On

The first duty of the engineer in a changing society is to keep civilization running. As in the theater, the show must go on. If, as some critics urge, science and machinery were abandoned and a few hundred thousand engineers were to quit for good, the whole structure of society would come down around our ears and when we pulled ourselves out of the ruins the life around us would resemble that of rural Russia under the Czars. By keeping society going, the engineer is giving evolution a chance to work.

Guesswork Must Be Stopped

The fundamental job of the engineer is to take the guesswork out of economic life as rapidly as scientific knowledge will permit. So far he has succeeded brilliantly with process and products, and this success is opening new doors. His next job will be to take guesswork out of the use of products and resources, out of their distribution as well as their production; also to take guesswork out of the use of capital and of manpower. The functions bring the engineer into more vital contact with what are called, somewhat optimistically, the social sciences. Our knowledge of man and of social institutions stands today about where our knowledge of physics and chemistry stood 2 centuries ago. Until a better equilibrium between technical and social knowledge is built up the safety of society demands a type of leadership in industry and the technical professions which is highly sensitized on the side of social welfare and ethics. It is the business of the engineering profession to supply this leadership. We constitute the dominant professional group in the industrial world. As a profession, society has a right to expect of us a certain disinterestedness of spirit, a devotion to truth wherever it may lead, and a conscious dedication to the good of society as a whole. We are expected to have the long view and not to live merely from balance sheet to balance sheet. We have a tradition of ethical accountability. We stand for the rule of science rather than intuitive guesswork. We are not doctrinaires and revolutionaries but have our feet on the ground of fact and experience.

The Engineer's Social Responsibility

It is a significant fact that every revolutionary movement in the world of today has tended to augment rather than narrow the engineer's sphere of social responsibility. This has been true in Russia, in Italy, in Spain, and in China. The concern of educators, in view of the present revolutionary outlook, is not so much to make our graduates more proficient in details, whether of technique or of management; it is to develop men who are able to deal in a more statesmanlike manner with the major economic and social problems of a technological era. As the writer sees it, the solution of this problem involves more than adding this or that to the curriculum or keeping the boys a year or two longer in college under the guidance of subject matter specialists. It involves a more organic conception of the whole process of recruitment, training and development within the profession—one that transcends the details of the arbitrary or accidental divisions of schooling and apprenticeship, the regulations of the licensing boards, and the rules of eligibility for the several grades of society membership.

It is encouraging to note that the joint movement now taking form among our national bodies for a scheme of professional certification looks in that direction. What is contemplated is a scheme of educational guidance that reaches down into the secondary school, bridges the college period, and covers the early years of professional activity, and which has as its objective a comprehensive appraisal of educational attainment at a mature level, as a qualifying standard for certification into the profession.

Many college men hope that this broader view, with its increased emphasis on further education after college, may so relieve the pressure on the undergraduate curriculum that a more profound grounding may be given in both the scientific and the societal groups of studies. Replacing this ground work with elementary management subjects will not solve the problem of a more adequate professional education. It may supplement it, and in a very valuable way. Courses in preparation for the management of industry are a legitimate adjunct to professional training in engineering, but if we are to remain a profession in the corporate sense and not become merely a fraternity of managers and executives, we must maintain the primacy of the sciences and of the philosophy of social institutions and relationships. We may keep our fellowship open to the administrative as well as the technical worker, but the nucleus of the profession must always be an intellectually qualified, scientifically grounded, socially intelligent body of men, bound by a strong code of ethical responsibility and devoted to an ideal of disinterested service, rather than the expediency of the next balance sheet.

The Institute and Its Members—Our Problems and Our Responsibilities

Many points of direct interest and prime importance to members of the Institute, individually and collectively, were discussed by President Skinner in the annual address before the summer convention. That the entire membership may benefit accordingly, the full text of the address is published herewith. ——The Editors.

By
C. E. SKINNER
PRESIDENT A.I.E.E.

THE AMERICAN Institute of Electrical Engineers is the youngest of the 4 major national engineering organizations of the United States. Its existence closely parallels the growth of the electrical industry not only of this country, but of the world, and its printed proceedings and transactions form the most important existing records of the development of the electrical art and industry of the country. These records cover a wide field, from the announcement of outstanding inventions and scientific discoveries in the electrical art to the commercial applications of electrical devices to every possible use in industry and society. The membership of the Institute from a very small beginning in 1884 has grown to a maximum of more than 18,000. The Institute's open forum for the discussion of problems, the announcements of discoveries, the work of its standards committee, and the work of its technical committees have been potent factors in the phenomenal development of the use of electricity throughout the nation. Electrical engineers interested in every possible phase of the art have given their time, their energy, and their best efforts to the work of our Institute.

The presidential addresses of my predecessors have covered an extremely wide range of subjects. They have dealt with abstruse scientific and technical problems. They have dealt with the status of the industry at the time the address was given; they have dealt with the idealism of the engineer, with pleas for recognition of engineering as a profession, with our relations to other engineering societies, and with many other subjects. I wonder how many members of the Institute have read and studied these addresses, other than the outgoing president who is faced with the constitutional requirement that he deliver an address and who, therefore, is interested in what his predecessors have said. Some of the finest things ever said before this Institute may be found in these addresses and I despair of being able to live up to the standards set by them.

From time to time the President of the United States issues a message intended primarily to call the attention of the Congress and of the people to the condition of the nation. In like manner, perhaps I can do no better than to call the attention of the Institute's membership to the state of affairs with which we as engineers are confronted. This requires that I outline a number of things which may seem to be more or less unrelated, but all of which I believe have a bearing on the present conditions and on the future of the Institute, and some of which are of importance to all engineers.

Acting National Secretary Appointed

The Institute suffered a severe loss during the year in the death of its national secretary, Mr. F. L. Hutchinson, who had served the Institute with ability, loyalty, and unflagging energy for a period of more than 28 years. The many appreciations of Mr. Hutchinson and his work that have been received indicate the high opinion in which he was held, both by Institute members and by others with whom he had come in contact. Some of these expressions have appeared in Electrical Engineering. The Institute's board of directors has given earnest consideration to the selection of Mr. Hutchinson's successor. It found itself in the fortunate position of having in Mr. Henline, assistant national secretary, a man familiar with Institute affairs and with the many duties of the office of secretary. As previously announced, Mr. Henline has been appointed acting national secretary as of June 1, 1932. Mr. Henline comes to this position at a difficult time brought about by a decrease in membership and revenue arising out of our disturbed economic conditions. The situation demands the most rigid economy in the conduct of the affairs of the Institute, with very little decrease, if any, in the amount of work required to carry on Institute affairs. I bespeak the loyal support of every member of the Institute for Mr. Henline in this new and responsible position.

Balancing the Budget

It will not be a surprise to any member of the Institute for me to say that there has been a considerable net decrease in our membership and in our income during the last year or two. Many of our members, as in every other walk of life, are unemployed and many of these are not in a position

to pay their dues to the Institute. There also has been a substantial falling off in the revenue from advertising in Electrical Engineering. Unfortunately, decrease in membership does not automatically decrease in proportion the necessary expense to serve the remaining membership. Consequently, the executive office, the board of directors, and the finance committee have found it necessary to make critical studies of every possible economy in order to maintain the service which every member has a right to expect from his membership. But, in spite of their best efforts, there will be a deficit at the end of the current appropriation year, and the following year may be still more difficult. Fortunately, through wise management during the past, there is sufficient reserve to meet the present deficit. However, a deficit cannot be continued indefinitely, and special studies are being made on ways and means of balancing our budget. Unlike our political friends, we cannot levy additional taxes. Consequently, budget balancing must be brought about through economies and through accessions to our membership. We must provide more service to our members, if this be possible, and at less cost.

Section and Branch Interest

During his administrative year your president has visited many Sections and Branches of the Institute. This has entailed a great amount of travel but it is hoped that the time, energy, and money have been well spent. It was most heartening to find in every Section and Branch visited an enthusiasm for the Institute and its affairs. An attempt was made to place before these far-flung units some of the problems of the Institute, particularly those in which they are vitally concerned. Special emphasis was placed on securing the cooperation and adherence of the younger members of our profession, and of the benefits which always follow their participation in Institute affairs. The arrangement of programs particularly adapted to the specific interests and needs of each local group was urged. This has been done to a very large extent in the past by these groups but no doubt even more can be done by careful planning in the future. The decentralization of Institute management and affairs by giving a large degree of autonomy to Districts, Sections, and Branches, makes it desirable that national officers of the Institute visit them from time to time. It has been an inspiration to your president to meet with the outstanding groups of engineers that compose these units scattered throughout the United States, Canada, and Mexico. I found no greater enthusiasm for, or loyalty to, the Institute than in the 2 Sections visited in Canada and the one in Mexico.

The committee on education has given loyal service to the Institute during the year and has been doing what it can to aid at this time when so many of the graduates of the electrical engineering departments of colleges and universities find it difficult, if not impossible, to secure employment. A very few years ago graduates could select any one of several positions offered. Today there are but few positions available, and many graduates of a few years ago are now hunting for jobs. In a recent radio address a prominent speaker congratulated the graduates of today on facing a time of adversity which brings out the very best that there is in men and which will be of inestimable benefit to them in their future careers. There are some definite records showing that graduates in times such as these have gone further, on the whole, than those of better times when positions were easy to secure and easy to hold. This should give some comfort, encouragement, and renewed determination to the engineering graduates of 1931 and 1932. In this connection I would like to second the recommendation made by a prominent educator, that recent graduates who are unable to find positions carry their education further, either by specialization in their chosen line or in business courses, if such additional schooling can be arranged. Such training will be of value in whatever field the engineer may find his life's work.

The Engineer in Business

During recent years undue emphasis perhaps has been placed on the desirability of a business career for engineers. This undoubtedly has resulted from observation of the outstanding successes of many high executives who are engineering graduates and who have had engineering experience. In spite of what will be said later in regard to the engineer taking his place in the councils of his community, the state, and the nation, which more or less presupposes training on broad cultural and business lines as well as in engineering, it is hoped that too much emphasis will not be placed by educators and others on a business career for engineers. The future undoubtedly will require for research, design, and construction, many highly technically trained engineers, who will find enduring satisfaction in work of this kind. Certainly some business training should be no handicap to the engineer, regardless of what his life work may be. In the future as in the past, men of engineering training undoubtedly will find high places in business administration, but also there will be outstanding careers for men who devote their lives to the more or less strictly technical side of engineering.

I would like to record here a specific recommendation which I have made to the chairman of the committee on education. This suggestion is that outstanding papers by students be repeated at other institutions when 2 or more Branches are within relatively easy travel distance of each other. Among the more than 1,000 talks and papers given by students during the year there are many that justify delivery before wider spread audiences and this would be accomplished by the adoption of the suggested plan. Such a plan should be a stimulus to authors and give those who are so fortunate as to be selected an invaluable experience, not only in writing and delivering papers, but also in meeting the criticisms and suggestions which undoubtedly would come from the delivery of such papers to groups in rival institutions.

Publication Policy

Two years ago the publication committee of the Institute concluded a searching inquiry into the question of our publications. As a result of this inquiry and recommendations coming out of it a very considerably modified policy was adopted, particularly with regard to our monthly publication now called Electrical Engineering, now 18 months old in its new form. In my visits to various parts of the country I have heard a great deal of praise for this publication and extremely few criticisms. These criticisms come mainly from those who believe that Electrical Engineering should confine itself strictly to technical matters and not include any commercial or so-called popular material. It should be remembered, however, that the membership of the Institute embraces individuals interested in every possible phase of the electrical art, from the most abstruse mathematical conceptions to the most common applications of equipment and devices in our daily life. Catering to this widely spread interest is no easy matter, but I feel personally that the editors of Electrical Engineering in cooperation with the publication committee have attained an enviable success with our national magazine, and have constantly improved it. It may be of interest to our members to know that during the past year we have printed more than 1,000 pages of text matter in Electrical Engineering, or, in our monthly edition of 23,000 copies, a total of more than 24,000,000 pages for the year. In our Transactions we printed more than 1,700 pages of text matter in an edition of 5,000 copies, or a total of approximately 9,000,000 printed pages. This compares very favorably with the amount of literature put out by the other national engineering societies. Also our expenditure for publications per member and per dollar received from dues is very well in line with the equivalent expenditure by the other societies.

History Should Be Written Now

At the 1932 winter convention in New York, I suggested that possibly the time had come to consider the writing of a comprehensive history of the Institute and of electrical engineering, particularly with regard to the formative years of the industry. This suggestion has evoked considerable interest and, as a result of several communications and suggestions, the board of directors authorized the appointment of a special committee to consider this subject and to report on the possibility and feasibility of such an undertaking. This committee consists of Dr. W. J. Foster, Dr. F. J. Sprague, and Dr. C. F. Scott (chairman). This committee has given some study to the question, but as yet has not presented a final report. A preliminary statement now in the hands of your president brings out several important suggestions, one or two of which I am quite sure the committee would be glad to have me emphasize here. Naturally, the task of writing a really comprehensive history is a large one and undoubtedly would result in the equivalent of an encyclopedia on the subject. The committee believes that one of the things most desirable to accomplish at the present time is to procure as much source material as possible from the pioneers who were a part of the great industrial drama of electricity. It is suggested that since the semi-centennial of the founding of the Institute occurs in 1934 it would be fitting and appropriate to have historical papers on the subject available by that time. I would like to urge those who are in position to do so to undertake the writing of such papers dealing with the specific phase of the subject with which each person is most familiar. Even a few pages of facts would be of value to our historians. The Transactions of the Institute and the files of the electrical trade press contain much of the technical material that will be required in the construction of the history which I have in mind. However, these papers contain but little of the human-interest stories which would go so far to make such a history really readable. They give little or nothing of the aims and aspirations, the trials and reverses, or the personalities and rivalries incident to these early struggles. Very few of us are fitted to write a story in finished form as we would like to see it appear, but there are few who could not put down in simple language that part of the story with which each is familiar and which, if filed with the Institute, would become of inestimable value in later years for the "Prescott" or "Motley" who becomes the eventual historian of the rise of the electrical industry. I would like, therefore, to urge the writing of as many biographies and autobiographies as possible even though these may never appear individually in print. Future generations would indeed be greatly enriched by having such documents in the archives of the A.I.E.E. as source material. Outstanding examples of such documents are the biographies of Dr. John A. Brashear and Mr. John Sweet, and the autobiography of Mr. B. G. Lamme.

American Engineering Council

Several previous presidential addresses have stressed the responsibility of the engineer as a citizen and the desirability of engineers bringing to bear on national and civic affairs the training and point of view that have made engineers so successful in their own fields in the past. Certainly at no time in our history has clear thinking, honest fact finding, correct deductions from these facts, and unbiased recommendations based thereon been so necessary as at present. Our amazing material progress during the last 50 years is due in large measure to the work of engineers. Whatever the causes that have resulted in the present conditions, there seems to be a wide-spread feeling that relief must come through the application of the engineering method. The American Engineering Council, of which the American Institute of Electrical Engineers is one of the constituent members, for many years has been endeavoring to help and guide in those larger problems which are beyond the limitation of any one national or local engineering society. Council has been endeavoring to give unbiased, constructive advice in national affairs which directly affect all engineers.

Outstanding studies by Council that have been completed, include "Waste in Industry," "The Relation of Safety to Production," and other studies. The most important study yet undertaken is now under consideration, namely, "The Balancing of Production, Consumption, and Distribution in Industry." It is expected that Council will divide this project into several units and, with the best talent that can be obtained in engineering circles cooperating with other interested agencies, undertake to arrive at definite conclusions in regard to some of the questions which have so disturbed the country, and even the world during these depression years. The Institute through its adherence to the American Engineering Council and to the Engineering Foundation is a party to and a supporter of this very great and worthy enterprise. It is hoped that the fact-finding method of the engineer, working with others interested, will result in the accumulation of sufficient real data on which economists, business men, and government agencies may base future action to prevent unduly wide fluctuations in the business cycles of the years to come.

The American Engineering Council has been fostering the organization of state councils along the same general lines as the organization of the American Engineering Council with the object in view of having such councils take part in state and local affairs in a manner similar to that of the American Engineering Council in national affairs. Such councils already have been organized in several states and your president, in his visits to various parts of the country, has been strongly urging the organization of these state councils. It is especially desirable at this time that such local councils study and endeavor to guide such state and municipal legislation as affects engineers and engineering, particularly as the cost of government in so many lines has been mounting by leaps and bounds with many projects proposed that are either unsound or unnecessary. Certainly no one is more competent to advise on engineering matters than are engineers themselves, and their advice will have weight if and when they are organized and when they advance arguments and opinions from the unbiased result of fact finding and not colored by self-interest. It is believed that engineers as a body are perhaps in a better position through their training and experience to divorce themselves from such self-interest than any other class of citizens.

Advice During Financing of Projects

During the boom years preceding the crash of 1929, many securities were sold to the public covering projects some of which had been condemned as unsound by prominent and reputable engineers. There were perhaps more of these projects in which such engineering advice was neither asked nor desired. Perhaps it may be admitted that some projects passed upon by engineers have proved to be unsound, but it is quite certain that sound engineering advice even during the boom days, if arranged for and followed, would have saved our citizens many millions of dollars now tied up in more or less worthless paper. The American Institute of Consulting Engineers for several years has been endeavoring to have investment bankers of the country secure advice from reputable independent engineers on projects being financed. This seems particularly desirable in connection with those projects for construction work in foreign countries financed by bond issues floated in this country. We are told that this practise has been generally followed by British financiers in making foreign loans; not only do they secure preliminary surveys and advice, but they usually have a definite follow-up after the loan is made to insure that the money so loaned is efficiently used for the project for which the loan was made and that the project is properly administered during the life of the loan. The wisdom of this recommendation seems so obvious that its desirability should not be questioned. Its omission has been disastrous to many who purchased such securities. While electrical engineers perhaps are less involved in matters of this kind than some others, yet undoubtedly electrical engineers have been and will be called upon for such surveys and it should be increasingly the practise of every investor to make sure that engineering and construction projects be so reported on and approved by independent engineers of the highest reputation for honesty and good judgment, before such investments are made.

There is a more or less constantly increasing number of states passing laws requiring the registration of engineers who practise within the commonwealth. This registration usually is required of engineers who undertake work in which the public health or safety in any way is involved. In my visits to various Sections, I have urged, and I again wish to emphasize, the importance of state engineering councils seeing to it that, so far as possible, proposed legislation for the registration of engineers be uniform, reasonable, and satisfactory to all parties at interest. This can be done only in cooperation with other national and state agencies when such legislation is under consideration.

Governmental Problems

The past few years have seen an enormous increase in the cost of government—national, state, and municipal. A very large proportion of the taxes collected for this expenditure is levied on organizations, facilities, and products with which engineers have had much to do. As these tax burdens become more and more onerous, engineers, along with all other citizens, have an increasing responsibility in endeavoring to see that taxes are reasonable and that monies so collected are efficiently spent. For many years engineers have been endeavoring to secure in the national government the consolidation of public works of various kinds now carried on by many unrelated and uncoordinated groups. The American Engineering Council has urged consistently the legislation necessary to accomplish this purpose. As Secretary of Commerce, Mr. Hoover strongly advocated the consolidation of such work under the direction of a highly qualified executive. As President he has repeated this recommendation in a

message to the Congress, and there is some hope that legislation soon will be enacted that will attain at least a part of the objectives so long advocated by engineers. The lack of such coordination undoubtedly has cost us much money, and has had its influence on the increased taxes which have been levied from time to time. Also, we are only too familiar with waste and extravagance, and even more serious problems involved in the handling of public works. I believe that organized engineers can do much to better conditions in those places where there is inefficiency, lack of coordination, and wasteful extravagance. They should join also with their fellow citizens in demanding honest administration under efficient leadership in all the affairs of those who govern us, and particularly those who are responsible for expenditures in which engineering has a part.

I have wandered, perhaps, rather far afield from the special interests of the American Institute of Electrical Engineers and its members, but I wish to emphasize as strongly as I can the point that electrical engineers—indeed all engineers—have in addition to the loyalty which is due their national organizations: a responsibility to their fellows, to the state, and to the nation. These responsibilities can be discharged only by engineers taking an intelligent and active part in all those affairs which affect them and their fellow citizens. The electrical industry in the past has had an outstanding part in the prosperity of this nation, giving its citizens facilities, comforts, and conveniences, such as never before had been known in any time or in any land.

In spite of the many difficulties and inefficiencies which surround us, we live in the finest country in the world. I am optimistic that we will be able to follow the example set us by our fathers and go forward to better government, higher ideals, better living conditions, and equal opportunities for all.

Educational Aspects of Engineering and Management

By R. E. DOHERTY
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In view of clear trends of experience—of the movement of engineers into management—shall we conclude that technical engineering has proved to be an effective and sufficient training at college for those who may later enter the field of management? Or, shall we consider it necessary to modify radically all engineering curricula in order to prepare men *primarily* for management? Or, again, and from the same experience, shall we plan separately for each? And, having answered this, what should the plan be?

THE GENERAL SUBJECT of engineering education has had searching and extensive study during the past fifteen years. Thus, there now exists a prodigious mass of material in all stages from raw data to carefully thought out conclusions and recommendations. As one attempts, by casual study, to form a rational opinion regarding educational policy as it relates to engineering and management, one is likely to become lost. At least this was the writer's experience.

A careful study therefore was undertaken of the new facts, their historical setting, and of the basic views underlying prevalent thought. From the perspective thus arrived at, a future educational policy, which seems appropriate to the writer, was framed. Since there are doubtless many others interested in this problem who have experienced a similar confusion in the face of conflicting opinion and the great tonnage of undigested data, it seems in order to present this study. There is one phase of the general problem which does not seem to have been considered seriously in previous studies, and that is the practicability of an effective training for general management in non-technical industry by other subject matter than technical engineering. This possibility is recognized in the present study.

Facts

The first step in the study was to ferret out and compare the major, relevant facts from the various surveys. The summary facts thus indicated, which apply certainly to mechanical, very probably to elec-

Essential substance of a paper (No. 32-75) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

trical, and possibly to most other engineering graduates, are as follows:

1. About one-half of all such engineering graduates by the time they have reached 40 years of age, have gone into industrial work primarily executive in character. These include two approximately equal groups:

   a. Those whose duties have *required* a substantial *technical engineering knowledge*.
   b. Those whose duties have not required such knowledge.

2. Only about one-quarter of electrical and mechanical engineering graduates have remained past 40 years of age in purely technical engineering work, involving practically no executive responsibility.

3. The rest, or roughly one-quarter, have gone ultimately into work such as teaching, selling, and consulting, all of which involve dealing with people.

4. Those who have gone into work involving executive responsibility (group 1) have, on the whole, received greater financial reward than those (group 2) whose work has not involved such responsibility.

5. Those in *general* management (group 1b) whose duties have been entirely administrative and practically non-technical have, on the whole, received much greater financial reward than any other group.

Three extremely important facts of general knowledge might be added:

6. Practically all college graduates, whether engineers or not, that have become successful in management have learned all they have known about it in practise. Formal college training in management, in the general sense, has existed only during recent years, and in only a few institutions. But it is steadily increasing.

7. Practically all engineering graduates, whether they have gone into some form of management or not, have encountered those human relations which are inevitable in the cooperative enterprises in which engineers engage.

8. The great technological progress of the last half-century has been based, first, upon the extension of scientific knowledge by scientists; second, upon the careful and rational application of this knowledge to the solution of practical problems by engineers; and, third, upon the organization by those in management of capital, physical facilities, and men for production and distribution.

In Retrospect

Industrial management and engineering are twin brothers; they have developed together. During this development, both industrial management and engineering naturally experienced a correspondingly extensive metamorphosis. The range in responsibility and in requisite talent, ability, and knowledge was multiplied a thousand fold. This extension of industry was upward, fan-like. The small factories and machine shops continued, but there was also tremendous growth both in size of organizations and in range of products in the expanding industries. This two-way growth necessarily demanded not only a commensurate increase in level of ability to handle the more complex management problems, but also a corresponding increase in technical knowledge and skill. In this expanding industry, including even those branches of non-technical character, the problems of both management and engineering called for less and less guesswork, and more and more rational treatment.

Under these conditions of growth there happened the thing which might have been expected. Practically all the conditions were favorable for the engineer to be called to management positions. He was geographically on the job; his distinguishing character stics—a scientific attitude of mind and method of approach—were among the foremost requisites; and, moreover, he was vitally interested because he not only understood the processes and the products, they were his creations! Hence by normal growth and evolution many engineers have come into administrative positions.

What has been the past relation of education to management? To what extent has engineering training been appropriate and adequate for management; to what extent, essential? Formal college training in industrial management is of recent origin, and hence has had very little, if any, influence in determining the present personnel in management. However, the character of engineering education undoubtedly has influenced it; how much, relative to the influence of other existing forms of education, is not altogether clear. How appropriate engineering training has been for those management positions for which technical knowledge *per se* has not been a requisite, either directly or as a stepping stone, is largely a matter of opinion. Only this is certain: to the extent to which a quantitative method and a scientific attitude and approach are requisite or desirable in management, engineering training is highly appropriate.

In relatively recent years there has been a growing recognition, in the educational policy of engineering colleges, of the all-pervading fact that the majority of engineering graduates have gravitated ultimately to some form of management. This recognition largely has taken the form of adding appropriate electives to the regular engineering curriculum, and in setting up new courses under such headings as industrial engineering, engineering administration, etc., in which the essential core has been engineering.

But there also has been a rapidly growing philosophy which would not recognize the essentiality of *technical engineering* subject matter in college preparation for general industrial management. It holds that a scientific attitude and rational method of analysis, which are recognized both as essential and as characteristic of engineers who have succeeded in management, can be developed on some subject matter other than engineering. This general idea has not yet taken full-fledged practical form, to the writer's knowledge, unless some of the business administration courses are so regarded; but it is being reflected in the gradual deletion of technical engineering matter from such courses as mentioned above, and the substitution of general management studies. So the presumably more direct and certainly less exacting college approach to management gradually is being set up.

The financial reward for technical leadership has been less than that for general managerial leadership. According to the statistics, the man who has been able to "run" things—to coordinate human activities effectively and to judge soundly—toward definite objectives has been valued more highly by leading executives than the man whose natural talents have been in a technical vein. Moreover, according to the facts, even those who could manage men and things in technical activity have received less financial reward than those in "general" management, in which technical engineering knowledge *per se* is either not essential or altogether secondary. Going still fur-

ther, those who have remained in purely technical work with no executive responsibility have been the most poorly paid. On the face of it, then, it would appear that in some fundamental way, mere association with technical matters relegates one to a lower stratum in financial reward.

However, that it has been so in the past should not be accepted as the establishment of an eternal fact. Random play of tremendous forces out of equilibrium have been the order of the day and we must be wary in drawing conclusions from experience of such a character. Nevertheless the clear implication is that something is wrong; technical engineering leadership has played too important a part in the past and obviously will be too much needed in the future to be overlooked now and smothered into insignificance under our intense enthusiasm for industrial management, which it largely created. It is not a question of merely giving such leadership its due; simply we should be stupid trustees, indeed, to the next generation if we created a problem for it by letting the present trend slip ahead unabated. Our first problem in this connection is to try to understand the past better. It is complex enough, but a thoughtful review does indicate, here and there, a rational thread running through it all.

Supply and demand, as it relates to the present subject, seems to be one such thread. In the mad rush ahead there has been a greater relative scarcity of managers, for whom no formal college training facilities had existed, than for technical leaders, for whom such facilities had been abundant. But scarcity for that reason, it should be observed, was only an accident; it was not a scarcity of natural management talent.

If much of the best brains turned to management and, moreover, if there yet continued to be a scarcity of management ability, it is not at all surprising that this should be reflected in financial reward. By and large, if those who entered management could do the technical work the others were doing and were also capable of managing, were they not more valuable?

Engineers who have remained in purely technical work—about one-quarter of all engineering graduates—have been poorly paid relative to all others. This probably can be justified. They have learned how to make certain routine calculations, drawings, or tests, or to operate some machinery, and they do these things day after day in a routine and satisfactory manner. Their work is important—indeed essential—but a four-year college education is hardly a necessary prerequisite. Those who have remained in such positions, for the most part, have not possessed the requisite qualities of a successful engineer; and, doing the work merely of a trained technician, they have been paid accordingly.

However, there is one element in this financial reward matter which does not fit in so well. *Creative*, technical engineering *leadership* has not been rewarded appropriately. There are two sides of technical leadership. One is technical management, which administers the day-to-day technical processes of operation, design, or calculation. The other is *creative*, professional leadership in technical matters. In this leadership is that small group of 10 per cent or so of scientists and engineers who are identified by *creative achievement*. They are the ones who can see through the technical mists which blind most of us; who thus provide the radically new concepts and methods, whether they be new forms of machines or structures, new ways of building these, or new principles and methods of predicting performance. These things are absolutely indispensable to technological progress in the same sense that the products of creative, professional leadership in management are absolutely indispensable. One whose head is a fountain of *creative* ideas is thus a technical leader, even if he cannot himself do much toward putting them into practical or material form. If he can, he is simply that much more valuable as a leader. The one quality rounds out and supplements the other. Either may predominate in equally valuable men—valuable as measured in terms of achieved results. Both functions are professional in character and are complementary in relation to each other; and therefore should be regarded more nearly on the same basis so far as reward is concerned than they have been.

However, there is a very definite, favorable trend in policy about these matters in some of the large industries, even if this is not reflected in the surveys; so there are indications that creative, technical engineering leadership is beginning to approach its proper estate.

Looking to the Future

When we orient ourselves in the direction of present trends and follow out those few clearly discernible lines from the past, they seem to lead to certain fairly definite indications. The foremost of these is that the future will have no less need than the past for leadership both in the scientific and technical fields of engineering and in management. On the contrary, the need will probably be greater; everything is getting more complex; each year it is becoming more difficult to see from one end to the other of this growing, technical-economic-social crazy-quilt with such thousands of complicated, overlapping and changing patterns. Minds trained *for leadership* will be all the more essential. Inventors must more and more have advanced scientific knowledge; the cream of invention has already been skimmed from the more obvious aspects of science, and therefore inventions will unquestionably become, in increasing measure, the product of scientists and engineers. The real leaders in technical engineering must also be more thoroughly trained in the basic sciences and in the rational applications of scientific principles to practical problems. Moreover they must learn to deal more effectively with other people, for it is a part of their job. And leadership in industrial management must likewise become broader in its outlook, more scientific in its knowledge, and more rational in its approach to general management problems. In a word, all professional leadership—not excluding law, banking, the clergy, and the rest—must broaden its outlook, perennially develop its scientific base, and improve its art; else, in the inexorable advance of complexity, the leaders will become even less able

than they are now to see across the boundaries. We all have taken hold of the technological bull's tail, and it is too late to let go; instead we've got to plan pretty quickly how to guide this brainless, powerful brute toward a rational objective, or he will presently distribute us prostrate over the terrain.

Another indication is that the same forces which have moved engineers into management will continue to do so, in a somewhat modified form, in the future. In the first place it will probably be modified by the influx of a new group which has not existed during the past growth of industry, namely, college graduates who have had formal training in the fundamentals of general management, but who have had little, if any, technical engineering training. In the second place, there will be the graduates of those existing courses which, although still designated—in most cases properly so—as "engineering" are intended primarily as fundamental preparation for industrial management. Such management courses should retain those elements which engender the method and attitude that have been characteristic of engineers, and which presumably have been the keynote of their success in management.

The tremendously wide range in types of industry surely affords openings in management for men of all degrees of technical training. Even in the most technical industries there are many administrative positions which require only a very limited technical knowledge; and the higher one looks in the organization, the more this seems to be so. Hence, if the colleges do a good job, it seems practically certain that within another generation graduates of engineering-management and other less technical courses will figure heavily in industrial management.

However, there is one point to be kept in mind. There should be at least some individuals in the high levels of general management who have an understanding and appreciation of technical matters and a sympathetic interest in research. These can come most effectively from former technical leaders. The half-informed business executive who disparagingly avers that he can get all the engineers he needs at $40 per week, or who naively believes that creative processes can be put on a mass production basis, is a misfit in modern industry.

What is the future for technical engineering graduates? Are they doomed? Not at all. On the contrary, their estate should become as attractive as any, if industry and the colleges adopt wise policies. Two important phases of management indubitably will be reserved almost exclusively for them, and all other fields will be open to them just as they have been in the past, except that the competition will be more keen. One reserved field is technical administration, which has always served as a stepping stone to higher levels. The other, and altogether foremost, is the creative, professional guidance and administration of technical and scientific progress. In this latter field also will be those technical and scientific leaders who may not be capable of management in its strict sense. These fields afford broad and extensive professional opportunities for technical engineering graduates; and adding to these fields the opportunity as in the past, to enter any other phase of management, the future possibilities for such graduates can be highly promising.

Future Policy

Educational policy cannot logically be separated from industrial policy; there are too many respects in which they are tied together. Most engineering graduates enter industry of one form or another, hence engineering colleges always have taken into account the requirements of the industrial job. When industry wanted graduates who were "practical," the colleges built workshops and tried to make their courses practical; when it changed its mind and insisted rather upon more "fundamentals," they gradually swung in this direction; and when it put large numbers of engineers into management, they worked out courses which would be preparatory to management. Thus any rational educational policy must give appropriate recognition to this interlocking of interests between the industries and colleges.

Moreover, an educational policy surely would be inadequate that did not recognize the often expressed hope that the engineer might sooner or later take an active interest in those unsolved, complex social and economic problems which his technology has largely created. What should that recognition be? Sociology, industrial history, and more economics? Undoubtedly this would be valuable to the engineer if he later took such an active interest, but those engineering graduates who have gone into business, banking, management, etc., have not done so because they have studied such subjects in college; forces of circumstance and, above all, a special type of qualification have combined to move them there. In all probability if the engineer ever takes an effective hand in the solution of such social problems, it will not be because he studied subjects relating to them as a major part of his curriculum; for if he did, he wouldn't be an engineer, by definition.

There is an unfortunate and illogical tendency to classify as engineering almost everything that is done thoughtfully. The two most distinguishing characteristics of engineers are straight thinking and an unqualified respect for facts. There seems to be a growing tendency in engineering circles to assume that these characteristics are inherently present in engineers and inherently absent in others; that other professional activities—general management, business, finance, etc.—become engineering when they are thoughtfully done; and that engineering training is the only sound educational basis for such activities. However, a statement probably much nearer the truth is that, although the definite laws and data of engineering are favorable to the development of such characteristics, nevertheless engineers develop these to a high degree simply because otherwise they cannot endure professionally. The necessity of developing fully such characteristics has been less pressing in other professions. Perhaps the latter may learn something from engineering. If so, good. But let us keep engineering as engineering, and not try to stretch its curriculum over the whole domain.

Some general observations should be stated now regarding college educational process, as the writer

views it. This is venturesome, because he is not qualified as either a professional educationist or a psychologist, and therefore may violate technical terminology and perhaps more; but it seems necessary, for the purpose in hand, to state in a layman's terms the more or less distinct phases of educational process as they appear to him. There are thus five largely parallel phases, as follows:

1. The first relates to the process of acquiring factual and definitive knowledge. One learns, for instance, the factors in the "flexure" formula in mechanics; the *definition* of "marginal utility;" that Disraeli was an English statesman. It is the process of building up one's mental encyclopedia. It is essentially a memory matter.

2. The second has to do with that type of reasoning in which the student is *led*, step by step, through logical processes either by a teacher or by a text-book. His part in this particular phase of his journey through the educational forest is not to move precariously along a trail which is only blazed; instead he rides on an educational sight-seeing bus over a modern, concrete highway of which even the curves and grades are reduced to a minimum. His only responsibility is to take due note of the scenery, and of the announcer's comments as he rides along. For instance, he may thus be escorted through the *logical development* of the "flexure" formula; of the *theory* of "marginal utility," or of the vector representation of alternating currents. This process is one of civilization's necessary short-cuts to the frontier of new things. In the process one's mental muscles are developed somewhat, but not under their own power.

3. The third phase is the process of acquiring skill in manipulation. For example, one develops skill in algebraic transformations; in numerical calculation from formulas by the slide rule; in operating a machine; or in carrying out an experiment. It is a discipline in procedure.

4. The fourth phase relates to that type of reasoning in which the student himself takes the initiative. *He* establishes the trail. The objective at first may be defined for him, and perhaps its general direction and a few landmarks may be indicated; but he presses through alone. In clearing away the undergrowth, in fording or swimming the technical streams which cross his path, in retracing his steps for a new start when he encounters an impasse, he not only exercises his mental muscles in worthy activity and stretches them to the elastic limit, but also develops his sense of direction and his power of discerning helpful landmarks. Each successive trail thus established *by him* increases his pioneering powers; and presently he will be able, if it is in him, to blaze his own trail through new areas to new objectives.

5. The fifth has to do with the establishment of a natural continuity between the development of the individual at college and after college. The branches of a truly educational program will neither terminate in dead ends here and there during the college course, nor be chopped off at graduation. Instead, they will feed *primary educational stems* which will continue and expand beyond graduation as long as the individual is on the ascending slope of his professional career. However, the extension of such stems after graduation is extremely difficult unless the student has already begun to extend them under his own steam before graduation. He must develop under guidance both the *desire* and *power* to extend them. This means a competent leader as a teacher, a curriculum well balanced for the purpose, and a plan obvious to the student.

Of the foregoing five phases, probably the first three are essential in the preparation for engineering work of any character; they are sufficient for *routine* technical activity, but the last two, in addition, are absolutely essential to progress toward any highly *professional* goal. If they are omitted at college, as they largely are, the graduate is obliged to provide them somehow after graduation, or else not reach the goal. To correct this situation—to provide phases 4 and 5—is, in the writer's opinion, the foremost problem confronting pre-professional education.

Turning more specifically to the engineering management aspects of educational policy, those students who would come within the scope of our subject can be classified under four divisions according to natural qualifications and appropriate education. It still may be very difficult practically to identify these groups completely, but they exist nevertheless, and every effort should be made to learn better to identify them. They are as follows:

Sub-Professional Group—Those primarily qualified by nature to carry out assigned tasks, either in technical work or in routine supervision. These comprise at least one-half of all college students that come under the scope of our subject. They comprise not only those whose intellectual qualifications limit them to such activities, but also those who don't want to do anything else. There are people of high intellectual ability who shrink from responsibility of any kind, or who are misfits, or who are plain lazy. They all seem to share a common level. The educational program for this group, excepting the misfits and the lazy ones, should be that of the technical institute which recognizes primarily the first three phases.

Professional General Management Group—Those who have outstanding natural powers of leadership and understanding, but relatively little technical leaning. This group may be expected to fill a portion of those positions of industrial and business administration—general management—which do not require technical knowledge.

Just what their educational program should be is a question largely outside the writer's knowledge. However, they must be well educated men of reasonable culture. Hence it is safe to say that there should be at least two, possibly three, stems: a cultural, a social, and economic, and possibly a slim technical one. The experiment of training men directly for general management is an interesting one, and should be encouraged. One great danger to be guarded against, of course, is the idea in students' minds that such a course provides the "royal road" to general manager or president.

Professional Engineering Group—Those who have outstanding natural talents along technical lines, some of whom have, in addition, the natural qualities of human leadership. From this group we should expect the future technical leaders; to some degree, leaders in general management and possibly also a few who would become actively interested in the larger social and economic problems.

Their program at college should have three stems—one main and two auxiliary: technical, cultural, and social and economic. The first and main stem should be a rigorous and thorough technical discipline. It should recognize all five phases; it should lay more emphasis upon the interpretation of fundamental physical laws and their application to the solution of illustrative problems than upon the memorization and use of standard formulas in connection with type-form cases; it should continually consolidate the gains achieved in all branches by feeding them into the main educational stem. For instance, in the junior and senior years it should make use of the results achieved in mathematics, physics, and mechanics, not in separate problems in as many classifications, but in engineering problems involving all. Past achievement would thus be unified with respect to the main purpose.

The cultural stem necessarily must be slim. But it can and should be vital. Perhaps the most that can be expected in the brief time available is to emphasize the technique of speech and writing (phase 3) and its fundamental purpose—namely, to express an idea clearly—and to *engender the habit and desire* of purposeful reading of historical, philosophical, and other cultural literature (phase 5).

While the social and economic stem is like the cultural in two respects, nevertheless it is of relatively greater importance. It is like the latter both in that it is auxiliary in character, and that the general educational purpose is gradually to establish the habit and desire of reading and thinking in a given field. In this case, however, it is about such practically important matters as industrial history, human relations in industry, sociology and economics of engineering industry and business. Taking courses in such subjects and letting it go at that is not enough; it must all be purposeful.

Professional Engineering-Management Group—Those all-round, capable men who have a definite technical leaning and also the natural qualities of leadership. This group, after graduation, may be expected to pass along the industrial, three-stage separator in which the first stage comprises the lower and moderate levels of technical activity; the second, technical management; and the third general management. Each stage will take its toll of men. And again, one would hope that some of these would ultimately become interested in general social and economic problems.

Their college program should have the same three stems as the *professional engineering group*, but there should be a fundamental shift in emphasis in two of them. This group should develop and retain the engineer's attitude and his respect for quantitative facts and measurements, because that attitude and respect will always be highly useful, and because technical engineering practise presumably will constitute the entrée to management responsibilities. However, the latter, being the main objective, should be given a corresponding weight in the program. Thus the social and economic stem should receive the same relative weight as the technical stem for the professional engineering group. For the present group, the technical stem should lay relatively greater emphasis on the first two phases; the social and economic should emphasize the last two phases. Analytical and pioneering powers should be exercised heavily on the subject

matter of the social and economic stem, so that this will have a vital growth after graduation. For illustration, take human relations in industry. Can you teach in undergraduate courses the professional technique of personnel management, or the art of getting along with associates? It would seem to be quite hopeless. But you can introduce the student to fundamentals, and exercise his analytical powers on actual personnel problems—all with the idea of developing a purposeful and enduring interest.

The cultural stem should presumably be the same as that for the *engineering group*.

Summary

During the development of industry, engineering and industrial management have evolved together. Certain phases of management, as the writer views it, have actually been a part of engineering; others have not. The direct administration of technical engineering activities *is* engineering in the same sense that the administration of personnel and procedure in a legal matter is law. However, we should not become confused; the further movement of engineers from such technical management to general management has not made the latter become engineering, any more than the movement of numerous lawyers also into general management has made it become law. It is still general management. Engineering and management are thus closely related, but all management is not engineering.

Looking to the past, the facts are that more than a quarter of engineering graduates have gone into general management; a quarter have remained in technical management, which is engineering; a quarter, in purely technical activity; and the rest in sales, consulting, teaching, etc. Those who have gone into general management have received the greatest financial reward; those who have remained in purely technical activity, the least.

Looking to the future, it appears that technical engineering graduates will have the same opportunity as in the past for movement into such positions, excepting that they will be in competition with graduates of courses designed as fundamental preparation for executive positions. There is a very real danger that both the prospect of a greater financial reward and the less exacting nature of these presumably more direct courses in preparation for management will cause many who are naturally qualified for such work and who will be needed for technical leadership in the next generation to turn from technical engineering courses. The problem of financial reward is one which the college cannot solve; industry must do it, not alone to give creative technical leadership its due, but, in industry's own interest, to prevent the source of technological progress from drying up.

For the purpose of defining educational policy, the students who fall within the scope of our subject can be broken down into four divisions: a *sub-professional* group, and three professional groups, namely, *engineering, engineering-management,* and *general management.* The educational program for the sub-professional group should be that of the technical institute. It should recognize primarily the first three phases of educational process—the acquisition of factual and definitive knowledge; the development of technique in manipulation and procedure; and the understanding of basic theory. The programs for the professional groups should recognize all five phases, and should emphasize particularly the last two—*viz.*, the exercise of analytical and pioneering powers; and the development of *primary educational stems*, and of the power and desire to extend and expand them after graduation. It is around these stems that the results of purposeful study and experience will be structurally articulated. The professional groups, it seems, should all have the same three stems: (1) cultural, (2) social and economic, and (3) technical. Merely the emphasis would be appropriately different.

The present inability completely to classify all students according to natural aptitudes should not discourage us. Such a classification is now possible to a limited degree. In any case *a* division is made; boys actually do choose to be engineers, lawyers, managers, etc., and college courses are set up to train them. A rational solution of the educational problem, it seems, can be approached only as we learn progressively to sift out types during the lower educational stages, and somehow help the individuals to find their way into activities along the lines of their natural aptitudes.

In a summary word, let us recognize the necessity of providing appropriate educational preparation for industrial management; but in our enthusiasm for this, let us not misinterpret past experience and thus fail to recognize another equal necessity; we must also provide both an appropriate educational preparation and a promising outlook for technical engineering leadership. Its contributions to technological progress surely bespeak a greater recognition than it has had. But mere justice is not the point here. It is a question whether, by a stupid perversion of emphasis now, we shall encumber the next industrial generation with the problem of a dried-up source of technical engineering leadership. Wide publicity of the new facts regarding attractive salaries in management, and the continued establishment—proper as this may be—of less exacting courses leading to management, will, it seems, inevitably discourage the more capable men from choosing technical engineering courses. The solution is not to suppress the facts or to discourage management courses, but for industry to recognize the situation, as some are beginning to do, and appropriately reward technical engineering leadership; in other words, to make such leadership a worthy and promising goal on its own score, and not merely as an entrée to general management.

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Conductor Vibration on Transmission Lines—I

Laboratory tests reveal some interesting characteristics of conductor vibration and its effect upon conductor life; common hardware accessories, and less-common vibration dampers, are shown to have marked effects. Mathematical analyses of the stresses in standard sizes of conductors as commonly used for electric power transmission lines check closely with these stresses as measured. Field experiments in conductor vibration will be treated in another article which will appear in a subsequent issue of ELECTRICAL ENGINEERING.

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FAILURE of conductor strands from fatigue induced by vibration has occurred in widely separated places throughout the world. Although but a small percentage of the total mileage has been affected, a study of the nature of the phenomenon and means of combating it is warranted. Any suspended cable, irrespective of material, span length, tension, size, or character of supports will vibrate under certain conditions. This natural phenomenon always has occurred, but only in recent years has it been recognized as the cause of fatigue failures formerly attributed to crystallization.

About 1925 when the importance of conductor vibration began to be appreciated, Aluminum Company of America started an investigation both in field and laboratory. The early results were included in two Institute papers by Theodore Varney. In the first ("Notes on the Vibration of Transmission Line Conductors," A.I.E.E. TRANS., v. 45, 1926, p. 791), a theory of the cause of vibration was presented which has received general acceptance; in the second ("The Vibration of Transmission Line Conductors," A.I.E.E. TRANS., v. 47, 1928, p. 799), reinforcement by armor rods was proposed as a means of protection. Recently several papers dealing with vibration have been published, particularly abroad. This article summarizes and interprets the results of laboratory work conducted by Aluminum Company of America since the publication of Varney's papers. It is planned to treat the field work in a subsequent article.

The problem of eliminating vibration troubles involves the consideration of several factors. Determination of these factors demands a better understanding of:

1. The actual stresses occurring in the conductors under field conditions.
2. The fatigue or endurance limits of the conductor materials.
3. The effects of various types of conductor accessories.
4. Practical means for minimizing the effects of, or preventing, harmful vibration.

With these considerations in mind many laboratory tests have been carried out during the past 7 years, under conditions quite comparable to those in the field. While this work by no means is completed, so much progress has been made that the results obtained should be of great interest to transmission engineers.

In the vibration laboratory of the Aluminum Company at Massena, N. Y., large concrete piers are provided so that 13 different spans of conductors may be tested simultaneously. The nominal length of each of these spans is 120 ft. Total tensions up to 20,000 lb. can be maintained on each specimen by means of suitable levers and weights. In addition to these, 4 50-ft. spans are available for tests on single wires and small stranded conductors. A general view of 1 wing of the laboratory, Fig. 1, shows some of the longer spans on the left and the 4 short spans on the right. A more recent installation of vibration equipment is shown in Fig. 2. Tests on these spans utilize higher frequencies than those carried out on the long spans; frequencies used for single wires on the 4 shorter spans are still higher, sometimes being as high as 7,000 vibrations per min. These higher frequencies are made possible by mounting an unbalanced flywheel directly on the specimen as shown in Fig. 3. Motion caused by the rotation of this flywheel is restricted to the vertical plane only. Variable speed friction drives permit the use of constant speed motors. For such tests,

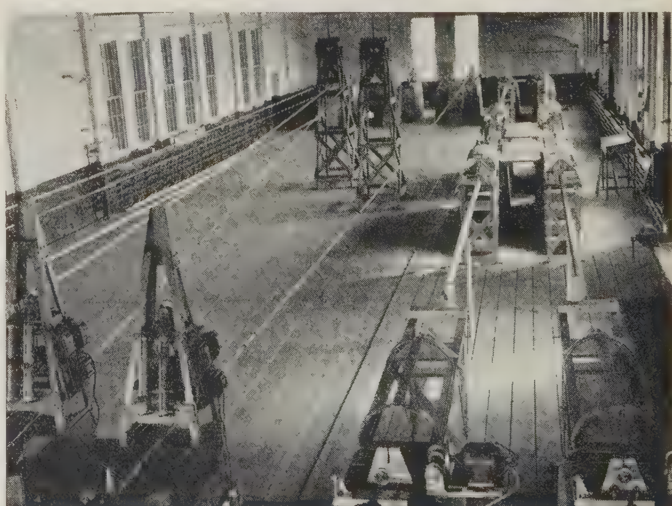


Fig. 1. One wing of the Massena, N. Y., vibration laboratory

Essentially full text of the first portion of a paper, "Vibration of Overhead Transmission Lines" (No. 32-90), presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

however, it is necessary that the speed of the driving unit remain constant within extremely narrow limits. To accomplish this it was necessary to install a special inverted motor-generator set. Many of the vibration tests have been made primarily to determine the comparative life of various sizes of conductors under severe conditions. A large mass of data is available, but the summarized results in Tables I and II for 2 sizes of A.C.S.R. (aluminum cable steel reinforced) are sufficient to illustrate several interesting facts. In the case of the 795,000-cir. mil A.C.S.R. vibrated in 7 loops on a 120-ft. span, each loop having an amplitude of $1^1/_8$ in., the marked increase in number of cycles required to cause failure as the cable tension is decreased should be noted. By reducing the tension from 18,000 to 15,000 lb. the life of the cable is almost doubled for all 3 test conditions. Similar increases were observed for still lower tensions. The data in Table II for 397,500-cir. mil A.C.S.R., vibrated under somewhat different conditions, emphasize this same fact. Further consideration of the data indicates that the outer strands must be severely stressed. This is especially evident in tests made using the square faced clamps. The repeated bending imposed on these specimens irrespective of the tensions used undoubtedly was more severe than occurs in the field.

Table I—Summarized Results of Vibration Tests

795,000 cir. mils A.C.S.R. $\left(\frac{54 \text{ x } 0.1214}{7 \text{ x } 0.1214}\right)$

Span: 120 ft. No. of loops: 7 Amplitude: $1\,^1/_8$ in.

Cable Tension, Lb.	Cycles for First Failure of a Strand in the Cable: Square Clamp	Bell-Mouth Clamp	Bell-Mouth Clamp With Armor Rods
18,000	433,000	1,148,000	24,000,000
15,000	796,000	2,078,000	40,538,000
10,000	1,166,000	6,242,000	95,400,000*
7,000	9,770,000	16,211,000	110,700,000*
5,000		75,200,000*	84,900,000*

* Test still running when this article was prepared.

Table II—Summarized Results of Vibration Tests

397,500 cir. mils A.C.S.R. $\left(\frac{30 \text{ x } 0.1151}{7 \text{ x } 0.1151}\right)$

Span: 120 ft. No. of Loops: 14 Amplitude: $^9/_{16}$ in.

Cable Tension, Lb.	Cycles for First Failure of a Strand in the Cable: Square Clamp	Bell-Mouth Clamp	Bell-Mouth Clamp With Armor Rods
7,000	3,775,000	11,289,000	49,910,000
5,000		26,380,000	176,100,000*
4,000	45,316,000	106,210,000	377,000,000*

* Test still running when this article was prepared.

Determination of Stresses

Adequate analysis of stresses in vibration conductors includes a consideration of the general phenomenon of vibration. The studies of such investigators as Varney, Relf and Ower ("The Singing of Circular and Stream Line Wires," Aeronautical Research Committee, *Report No. 825*, March 1921), and Ryle ("Conductor Vibration," *Inst. of Elec. Eng.*, Dec. 1930) certainly have helped to make possible a better understanding of this phenomenon. To determine whether or not under any given set of conditions the fatigue limit of the material in any conductor will be exceeded, it is necessary to know the location and magnitude of the maximum stresses. If stresses exceeding the fatigue limit are repeated many times, failure eventually will occur, the time depending upon the magnitude of the stresses.

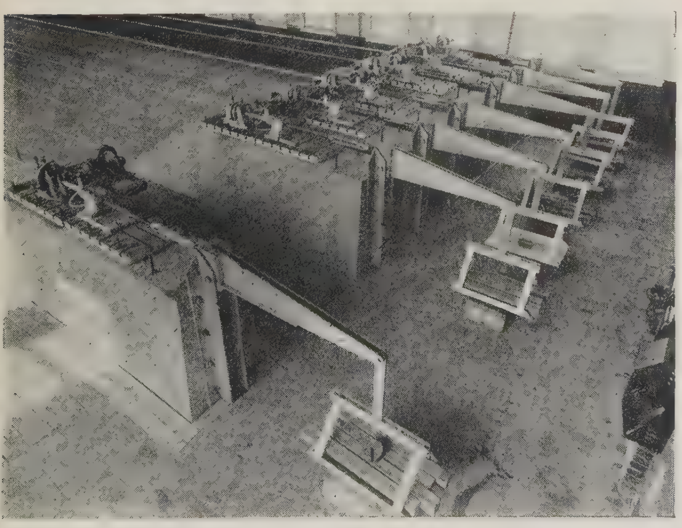


Fig. 2. Method of loading cables in tension

The most direct method of evaluating the stresses in a cable under given conditions of vibration is by actual measurement. While at first thought this may appear impossible because of the limitations of available strain measuring apparatus, it has been found feasible by preparing and testing special large specimens, geometrically similar to those of usual size. So far 2 such specimens of 7-strand conductors have been fabricated and tested: One is a 7-strand hard drawn aluminum cable, each wire being 0.375 in. in diameter and possessing mechanical and electrical properties identical with those of standard conductors; the other is A.C.S.R. composed of 6 strands of the same wire stranded over a single steel wire. Using a span of 120 ft., these specimens have been tested with various tensions and frequencies.

It was found that these large specimens could be set in a steady state of vibration, and the position of the top and bottom of the cable at any desirable distance from the end support determined accurately by measuring with micrometer calipers the distance to suitable reference planes. The position of the cable for different test runs could be checked within a few thousandths of an inch, and from the measurements the deflection curve for the cable could be determined accurately when vibrating as well as when not. It was then comparatively easy to displace the cable under suitable static loads to the same extreme positions it assumed while vibrating. Strains measured with the cable in the deflected positions should correspond closely with those in the cable during vibration. A comparison between the measured and computed positions of the cable near the clamped end, while vibrating, is shown in Fig. 4. Cable positions resulting from static loading are so nearly identical that the differences cannot be shown in this diagram.

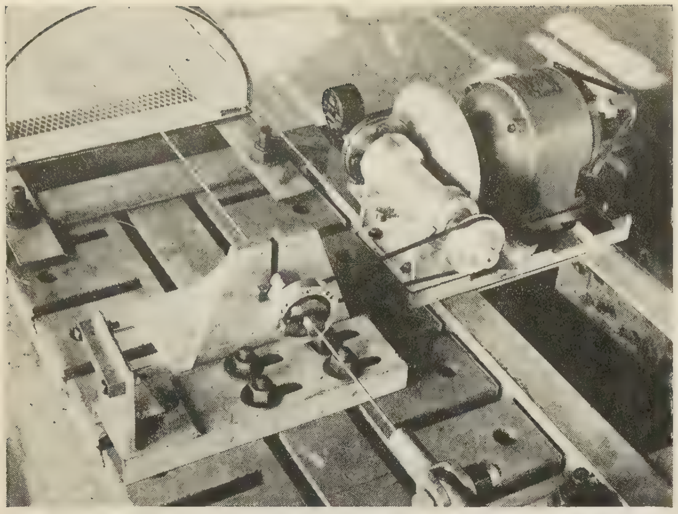


Fig. 3. Unbalanced flywheel for high frequency vibration of wires and small cables. Note variable speed friction drive

By using specimens having such large strands it was possible to attach Huggenberger tensometers, using a $^1/_2$-in. gage length, to the outside strands at various positions with respect to (1) the distance from the supports, (2) the circumferences of each strand, and (3) the circumference of the conductor as a whole. Successive applications of load together with attachment of the tensometers at various points permitted a detailed evaluation of the stresses (strains $\times$ modulus) obtaining throughout the conductor. A representative set of such data for 3 positions of the cable is plotted in Fig. 5.

Mathematical Analysis of a Vibrating Cable

Formulas for the general behavior of a vibrating cable already have been given by Varney. The following mathematical analysis has been developed by R. G. Sturm of the Aluminum Research Laboratories.

The frequency at which a cable will vibrate in a loop length, L, is equal to

$$f = \frac{6}{L}\sqrt{\frac{Tg}{W}} \tag{1}$$

where

f = frequency in cycles per sec.
L = loop length or distance between node points in in.
T = total tension in cable in lb.
W = weight of cable in lb. per ft.
g = acceleration due to gravity in ft. per sec. per sec.

Stresses from each of the following sources will be considered independently and the total stress taken as the sum:

1. Stress resulting from direct tension in the cable.
2. Bending stress resulting from the static sag of the cable.
3. Bending stress resulting from the deformation of loops during vibration.
4. Increased tensile stress caused by the increase in length of arc of the vibrating cable.

In order to facilitate following the steps in arriving at theoretical values of stress, each source of stress is considered separately.

1. Stress resulting from direct tension depends upon the ratio of steel to aluminum and to a certain degree upon the stranding of the cable. For a solid rod or for a cable in which the strands are all of the same metal this stress may be computed by simply dividing the total load by the area of cross-section, i. e.,

$$S = \frac{T}{\text{area}} \tag{2}$$

If the cable is bimetallic the stresses in the different materials and the effect of stranding may be determined as outlined by G. W. Stickley ("Stress-Strain Curves for Transmission Line Conductors," Paper No. 32-68, A.I.E.E. summer convention, Cleveland, Ohio, June 20-24, 1932).

2. Bending stresses resulting from the weight of the cable will be practically negligible throughout the central portion of the span but might be quite severe near the clamps. In general these stresses are neglected, but in some transmission lines they may be far from negligible. If the cable is clamped rigidly in a horizontal position at the end (which is probably a more severe condition than generally exists in actual service) the bending moment at the clamp may be expressed by the equation:

$$M_0 = w\left(\frac{L_s}{2K} - \frac{EI}{T}\right) \tag{3}$$

where

M_0 = bending moment at the clamp in in.-lb.
w = weight of cable in lb. per in.
L_s = span length of the cable in in.
EI = flexural rigidity of the cable which depends upon the stranding conditions, but for a solid rod would be the modulus of elasticity times the moment of inertia of cross-section in lb.-in.^{2}
T = total tension in the cable in lb.

$$K = \sqrt{\frac{T}{EI}}$$

The stress resulting from the bending moment, M_0, may be figured by the bending moment formula,

$$S = \frac{M_0 c E_0}{3EI} \tag{4}$$

where

E_0 = modulus of elasticity of the material in the outer strands in lb. per sq. in.
EI = flexural rigidity of the cable in lb.-in.^{2}
c = half of the outside diameter of the cable in in.

The value of EI for a stranded cable cannot be determined analytically because of the interplay of the strands upon one another. The effect of the stranding is not entirely independent of the tension applied to the cable and, therefore, must be determined for the average working tensions under which the cable will be used.

In order to determine the values of EI for stranded cables, load-deflection tests were made on the center section of a long cable. A span length of at least 6 times the lay of the cable was chosen in the center portion of the span. Supports were blocked up under the cable and the cable clamped to the supports after the tension had been applied. Transverse load then was applied to the mid-point of this secondary span and deflection readings taken for increments of load. Ordinary beam formulas for determining these deflections no longer hold because of the relatively large direct stress in the member. Setting up the differential equation representing equilibrium and continuity in the beam, it is found, however, that

$$\frac{d^2y}{dx^2} - \frac{T}{EI}y = \frac{M_0}{EI} - \frac{PL}{4EI} + \frac{Px}{2EI} \tag{5}$$

where

P = load at the center of the intermediate span in lb.
y = deflection in the direction of the load in in.
x = distance from the left end of the intermediate span in in.

and other terms are as previously defined.

A solution of this equation gives not only the shape of the deflected cable but also the equation for bending moment at every point in the cable since

$$M = EI\frac{d^2y}{dx^2} \tag{6}$$

The boundary conditions that must be satisfied are that the deflection at the clamped ends be zero; the slope at the clamped

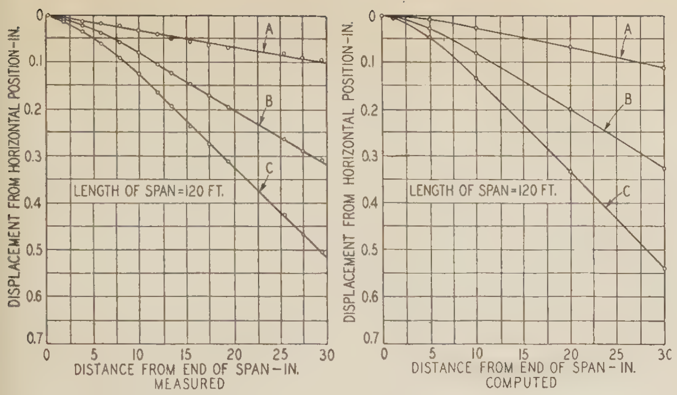
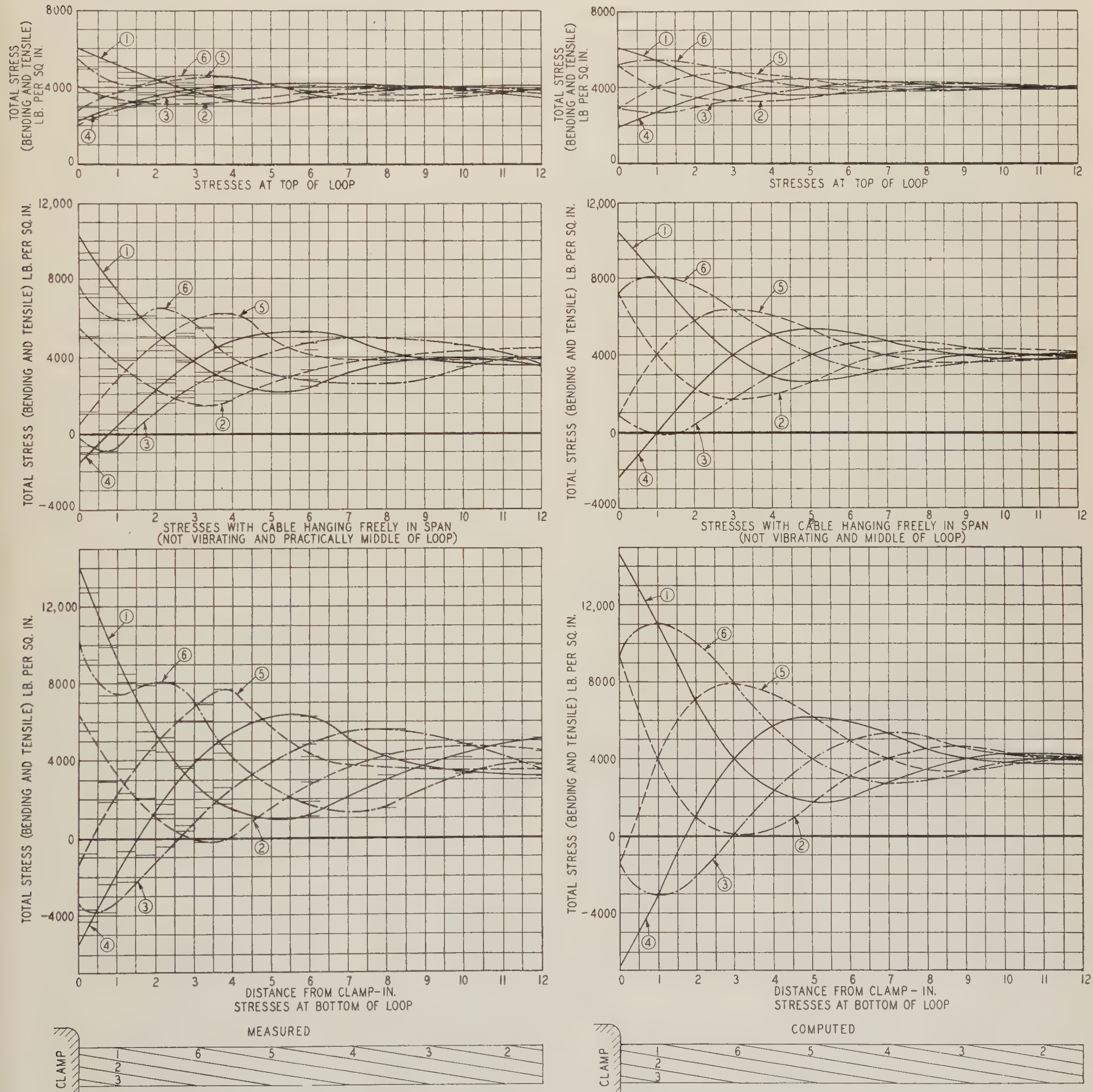


Fig. 4. (Left) Comparison of measured and computed deflections of cable. Measured values are shown at the left; computed values, at the right

A—Upper position when displaced either statically or by vibration (7 loops—1 $^1/_8$-in. amplitude)
B—Natural or free position of cable
C—Lower position of cable when displaced either statically or by vibrations (7 loops—1 $^1/_8$-in. amplitude)

Fig. 5. (Below) Distribution of stress in the strands of a typical cable. Measured values are shown at the left; computed values, at the right



Cable tension 6,000 lb.
Tensile stress in aluminum 4,000 lb. per sq. in.
Length of span 120 ft.
Length of lay of cable 12 in.
Clamp at end of span square

Stresses in the different strands of the cable at the top and at the bottom of the loop, respectively, were determined for the cable deflected statically to the same position as when it was being vibrated in 7 loops and with 1 $^1/_8$-in. amplitude

end, zero; and the slope at the middle of the span, zero. The resulting solution gives

$$y = \frac{P}{2KT\left(e^{\frac{-KL}{2}} + 1\right)}\left[- e^{-Kx} + e^{-K\left(\frac{L}{2} - x\right)} - 1 + e^{\frac{-KL}{2}}\right] + \frac{PL}{4T} - \frac{Px}{2T} \tag{7}$$

Maximum deflection at the center is

$$y_m = \delta = \frac{P}{KT}\left[\frac{KL}{4} - \frac{1 - e^{\frac{-KL}{2}}}{1 + e^{\frac{-KL}{2}}}\right] \tag{8}$$

Knowing the load P at the midspan, the tension T on the cable and the deflection δ for any given span length, it is possible to determine the corresponding value of K and from this the value of EI for the cable. The values of EI thus obtained may be tabulated for use in the stress formulas.

3. Stresses at the clamped ends or points of support caused by vibration may be computed on the basis of the static conditions that will produce a deformation of the cable identical with that occurring during vibration. It may be shown that the deflection of a span of length L (the loop length) loaded with a load P_1, which will give a deflection equal to 0.7 times the vibration amplitude, will give the conformation desired at the clamped end. From the equation

$$\delta = \frac{P_1}{KT}\left[\frac{KL}{4} - \frac{1 - e^{\frac{-KL}{2}}}{1 + e^{\frac{-KL}{2}}}\right] \tag{9}$$

the value of P_1 which will give a deflection δ, equal to 0.7 of the amplitude first is found; then the bending moment at the edge of the clamp may be computed from the formula

$$M_0 = \frac{P_1}{2K} \cdot \frac{1 - e^{\frac{-KL}{2}}}{1 + e^{\frac{-KL}{2}}} \tag{10}$$

where the terms are as previously defined. The stress resulting from this bending moment may be computed by means of eq. 4. It should be noted that this stress is oscillating and produces equal stress components in opposite directions on top and bottom, both being subjected to alternate tension and compression. The stresses throughout the length of cable resulting from the bending during vibration may be computed from the formula

$$S = 2\pi^2 E_0 \cdot \frac{c}{L} \cdot \frac{A}{L} \tag{11}$$

where A = amplitude of vibration in in., and the other terms are as previously defined.

4. As the cable distorts into waves while in vibration, the length of the cable around the arcs will be greater than the length when not vibrating. The additional length thus required will result in a stretching of the cable because, in general, the clamped ends cannot yield rapidly enough. This additional length results in a unit deformation which is quite closely expressed by the formula derived by Bechtold and Folkerts ("Resistance of Cable to Transverse Vibration Especially Hollow Overhead Cable," Elecktrotech. u. Maschinenbau, July 14, 1929, p. 593).

$$\epsilon_s = \frac{8}{3} \cdot \frac{A^2}{L^2} \tag{12}$$

where ϵ_s = unit elongation of the cable, and other terms are as previously defined. The resulting stress then may be computed as

$$S = \frac{8}{3} E_0 \cdot \frac{A^2}{L^2} \tag{13}$$

in which E_0 = modulus of the cable as a whole.

This stress is simply an increase in tension of the cable which in general is quite small but which may not be negligible in many cases.

By proper combination of all of these stresses the total stresses in the vibrating cable may be computed with a fair degree of accuracy. Stresses actually measured in a cable with those computed on the basis outlined, are shown for comparison in Fig. 5. It may be noted that stresses measured on the top part of the cable, i. e., where tensile stresses are great, are slightly lower than the theoretical stresses; whereas on the under side of the cable, where compressive stresses exist, measured stresses are somewhat greater than the computed stresses. This difference is due to the fact that the tensile stress tends to pull the strands closer together, whereas the compressive stress causes them to push out thereby tending to move the neutral axis toward the top of the cable.

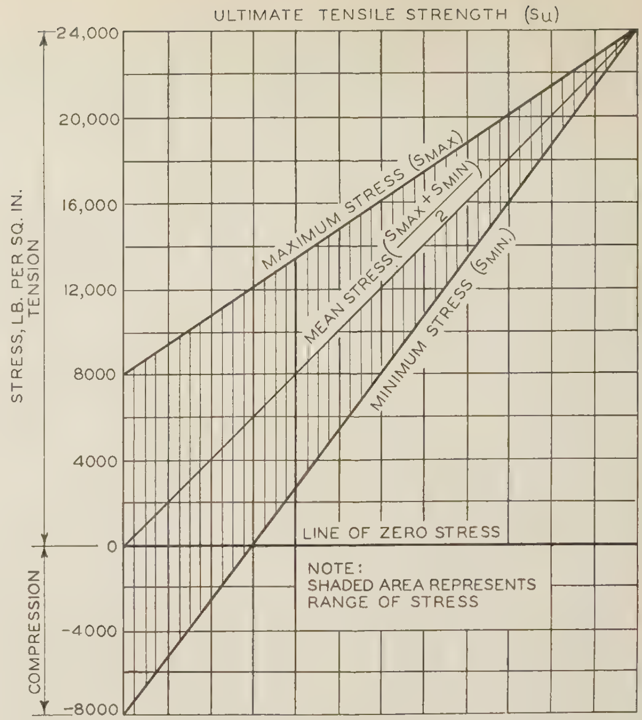


Fig. 6. Goodman diagram showing safe mean stress and safe range of stresses for aluminum conductor

It has been found quite feasible to measure with suitable accuracy the deflection curves and determine EI values for all sizes of commercial conductors. Following the general procedure just outlined measurements of stress can be made on the smaller sizes of cable. This work is now in progress and the limited results obtained to date indicate that the theoretical analysis may be accepted with assurance.

In applying this study to transmission line problems it is important to remember that no allowance has been made for relief of stresses caused by the sympathetic motion of the cable supports. The supports used for tests were practically rigid, whereas supporting clamps and insulator ties used on actual transmission lines are far from rigid.

Fatigue Properties of Materials

Assuming that the limits of the stress ranges for the critical section in a cable can be determined, it is desirable to know the safe limits of the stress ranges for the materials in the cable. This information is obtained best from vibration tests of single wires under various known conditions. Such tests

are essentially fatigue tests in which both the mean stress and the stress ranges may be varied widely.

Tests show that when the mean stress is zero the endurance limit based upon 500 million complete reversals is 8,000 lb. per sq. in. for hard drawn aluminum conductor metal. Using this value and the Goodman diagram which, although not checked thoroughly by experimental data, has been found to give safe values, limiting ranges of stress are obtained as shown by Fig. 6. This diagram shows that as the mean stress increases from zero to the ultimate strength of the material (24,000 lb. per sq. in.), the safe range of stress decreases from 16,000 lb. per sq. in. to zero at the ultimate strength. Tests on single wires are now in progress for the purpose of checking the Goodman diagram both for hard drawn aluminum and for steel; but because of practical difficulties in carrying out the tests, results are being obtained rather slowly.

Effects of Conductor Accessories

Many tests have been made for the purpose of determining the effects of various types of fittings on the vibration or fatigue life of electrical conductors. Space limitations, however, permit the inclusion of only a few of the results in this article. Effects of bell-mouth clamps in increasing the life of vibrating cable are well illustrated in Tables I and II where the number of cycles for failure is shown for cable with square clamps and with bell-mouth clamps. It may be noted that the life of the cable has been practically doubled in every case. This is explained by the fact that the bell-mouth clamp prevents the severe concentration of stress that occurs in the square clamp. If armor rods are used with bell-mouth clamps the life of the cable is increased many times, as illustrated also in Tables I and II. While these tests have not been completed they have run long enough to demonstrate the effectiveness of armor rods as a means of overcoming vibration troubles.

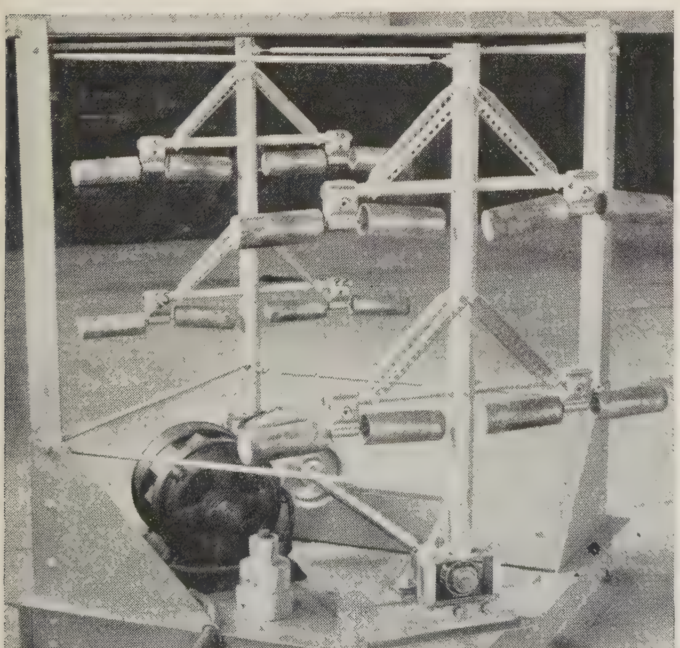


Fig. 7. Vibration damper fatigue testing machine

Note that the vibrating members are driven through 2 eccentrics, one of which can be seen at the lower right

It is possible by means of dampers to eliminate practically all the vibration in a cable. Laboratory work on vibration dampers has included extensive tests to determine the relative life of various dampers of the Stockbridge type using the special fatigue testing machine shown in Fig. 7. The machine can be operated at various speeds from about 600 to 1020 r.p.m. using any amplitude from zero to $^1/_2$ inch. Tests with this machine permit the selection of proper cable for supporting the weights and assist in refinements of design.

Another special testing machine was built for measuring the efficiency of various types and sizes of vibration dampers. This was to be done by measuring the rate of retardation of a flywheel after it and the attached damper (the damper being driven through an eccentric) were brought to a definite high speed and then disconnected from the driving motor. So far the test data have not been satisfactory for determining the efficiency of dampers, but have given valuable information relative to critical frequencies of dampers.

Dampers of the Stockbridge type (Fig. 7) have 2 critical or natural frequencies which are dependent upon the material, size, length, and stranding of the damper cable as well as upon the size and shape of the weights, and the method of attaching them to the damper cable. Computed frequencies for these devices have been found to agree with observed frequencies within the limits of experimental error. The amplitude of oscillation of the damper weights for any given forced vibration of the center clip depends upon the frequency of the forced vibration and the damping characteristics of the damper cable. With the damping characteristics of the damper cable known this amplitude may be computed and from that the energy absorbed per cycle or per second may be determined. This value together with the forces developed by the vibrating weights will give criteria for selecting the most suitable damper for any given conditions. Space limitations do not permit giving the mathematical analysis in this article.

Conclusions

The following conclusions summarize the principal findings of the laboratory investigation treated in this article:

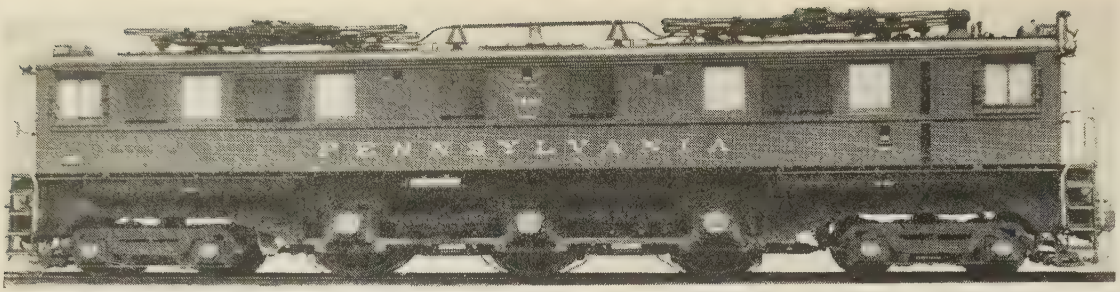
1. Satisfactory methods have been developed for measuring actual stresses in vibrating conductors under conditions closely simulating field conditions.

2. A mathematical analysis of the stresses in a stranded conductor under vibration is given which checks closely with measured values.

3. Tests indicate that safe limits for stress ranges of conductor materials can be determined satisfactorily.

4. Certain types of hardware accessories have marked effects upon the life of vibrating conductors.

Editor's Note.—The last portion of the paper "Vibration of Overhead Transmission Lines," which deals with *field tests* on actual transmission lines, will be covered in a later article to appear in a subsequent issue of Electrical Engineering.



Heavy duty type P5 electric passenger locomotive for service on the Pennsylvania Railroad's New York-Washington line which now is being electrified

Electric Locomotives for the Pennsylvania

High sustained available and controllable continuous output is considered one of the outstanding characteristics of locomotives recently designed for the Pennsylvania Railroad. This high output has been made possible by the use of motors of improved design together with transformers having suitably selected taps. Important features of these locomotives are treated in this article.

By
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Philadelphia, Pa.

HIGH sustained output, interchangeability of principal parts, accessibility of parts for inspection and repair, and the unit type of construction are some of the outstanding features of electric locomotives recently designed for the Pennsylvania Railroad for use on its New York-Washington line now being electrified. Recent advances in the design of single phase a-c. commutating motors have made it possible to mount the motors between the driving wheels, resulting in a simpler, lighter, and less expensive a-c. locomotive than had been used previously on this road. Three classes of locomotives have been designed to meet varying operating needs.

In 1915 at the time the single phase a-c. system was constructed on the main line between Paoli and Broad Street, Philadelphia, it became evident that the type or types of single-phase electric locomotives best suited for general use on the Pennsylvania system would have to be determined. Electric locomotives previously developed for this railroad were designed primarily for operation in the New York terminal area. The resulting engineering studies led in 1924 to the adoption of an electric locomotive known as the L5 type, designed primarily as a general utility locomotive for the railroad as a whole. This locomotive was so arranged that by a modification of gear ratio it could be used in either passenger or freight service; and by modification of the control, it could be used on either alternating or direct current.

After extensive tests, several of the L5 locomotives were built and placed in service in the New York electrified territory. They were designed with single phase commutating motors and control equipment suitable for operation on direct current. At the same time another was equipped for operation on alternating current and placed in service in Philadelphia.

Advances in the design of single phase motors since the adoption of the L5 locomotive have made possible the development of a simpler, lighter, and less expensive a-c. locomotive. These many improvements have been incorporated in locomotives recently designed for use on the Pennsylvania between New York and Washington. In Pennsylvania Railroad nomenclature the electric locomotives to be used in this service are designated as follows: Class P5, heavy duty passenger service; Class O1, light duty passenger service; Class L6, freight service; and Class B1, switching service.

Class B1 switcher developed some years ago has been built in quantities. It is giving satisfactory performance in both a-c. operation on the Long Island and Pennsylvania railroads, and in d-c. operation on the Pennsylvania Railroad. With slight modifications this locomotive will continue to be used for extensions in switching service.

The P5, O1, and L6 locomotives are those recently designed. This article is devoted chiefly to a description of the principal features of the P5 locomotive. The more important questions affecting the design of all 3 of the locomotives are brought out, however, and by reference to the other 2 classes the relationship between the 3 is shown. Before proceeding with the actual design of the P5 locomotive, decisions on several important questions had to be made; these are as follows:

1. Weight on drivers.

After study and review of steam locomotive practise, it was decided to aim at a weight of 75,000 lb. per pair of drivers and a total locomotive weight of 375,000 lb. Consideration was given to the mechanical structure of the locomotive, the speed at which it was to operate, and to the structures and physical characteristics of the railroad over which the locomotive would be used.

Written especially for ELECTRICAL ENGINEERING; based upon an oral presentation before the transportation group of the A.I.E.E. New York Section. *Not published in pamphlet form.*

2. Selection of electrical equipment.

Single phase commutating type motors were selected for driving the locomotive. In selecting these as well as the other electrical equipment, consideration was given to the best method of taking full advantage of the permissible weight on drivers, both in regard to horsepower and tractive effort, and to secure a proper balance between these factors and the capacity of the electrical equipment.

3. Horsepower and tractive effort.

In deciding upon these features, consideration was given to the horsepower and tractive effort of a steam locomotive that was handling through passenger trains successfully; it was felt that if an electric locomotive could be built with the same or better horsepower and tractive effort than that of this particular steam locomotive, the resulting electric locomotive would provide a satisfactory unit for handling through passenger trains.

4. Maximum speed.

To provide operating tolerances over present speed, and at the same time permit increased operating speeds in the future should they prove justifiable, a maximum operating speed of 90 miles per hr. was selected.

5. Adhesion factors.

Conservative design required the use of an adhesion factor of 25 per cent of the weight on the drivers. Experience with electric locomotives in the past indicated that this adhesion factor could be reached without trouble under almost any normal operating conditions.

In the earlier Pennsylvania locomotives of both a-c. and d-c. types, for various reasons jack shafts and side rods had been used as the means of transmitting the motor output to the driving wheels. In d-c. locomotives this was done to secure a smooth riding vehicle as well as to concentrate the driving power in a small number of large motors. In the a-c. locomotive, similar construction was used to permit the use of a minimum number of large motors, since when these locomotives were designed it was not possible to place between the driving wheels sufficient motor capacity to handle the tractive efforts made available by the permissible weights on drivers. Developments in single phase motors, however, now permit the installation between the driving wheels of sufficient motor capacity to handle effectively the maximum weight per pair of drivers; jack shafts and side rods thus are no longer necessary, and it is possible now to design a maximum driving unit of sufficient capacity to develop the tractive effort available with the allowable weight per driving axle.

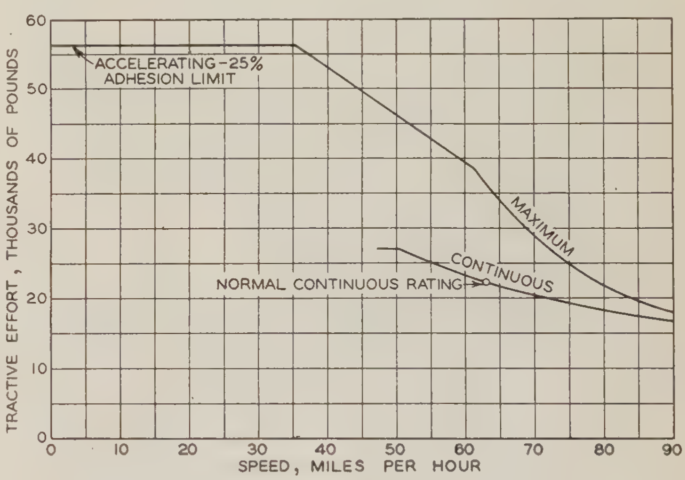
Improvements in A-C. Locomotive Motors

Among developments that have made possible the increase in motor capacity referred to, may be mentioned an increase in permissible peripheral speed of both armature conductors and commutator. This increase in safe peripheral speed resulted from improvements in the mechanical design of both armature and commutator, the use of roller bearings for the armature, and improved mechanical design of gears and pinions. Another development that has contributed to the increase in motor capacity is an increase in the efficiency of forced ventilation, which has followed upon a detailed study of air distribution through the various air passages in the motor windings.

With the selection of this improved driving unit as a base, it has been possible to design locomotives of different classes for freight and passenger service, each with a suitable multiple of these driving units assembled in combination with appropriate idle trucks. Thus in the P5 locomotive, a motor unit consisting of 2 armatures and stators in a single frame was selected as the motive power for a pair of drivers, the motors driving the wheels through an adaptation of the well-known quill drive. In the O1 locomotive, identical units are used with fewer drivers. In the L6 locomotive, single motors mounted in a frame suitable for axle mounting drive the wheels by means of conventional gear reduction arrangements.

As the design of the P5 locomotive progressed it was found that 3 pairs of drivers, each pair equipped with the motor unit just described, with a 4-wheel truck at either end of the locomotive, provided somewhat greater capacity than the present through steam passenger locomotive known as the "Pacific" type. It was found also that an assembly of 2 sets of twin motors with 2 pairs of drivers and a 4-wheel truck at either end, classification O1, provided a locomotive of somewhat greater capacity than the through steam passenger locomotive known as the "Atlantic" type. An assembly of 4 pairs of drivers of approximately 60,000 lb. per pair having a single armature driving each pair through gears and pinions, with a 2-wheel truck at either end of the locomotive, provided a capacity somewhat greater than that of the "Mikado" steam locomotives used in freight service on the Pennsylvania system.

In addition to the foregoing, the designs selected permitted great flexibility of motive power: In an O1 locomotive, 2,500 hp. is available with 2 pairs of drivers; in the P5 locomotive, 3,750 hp. is available with 3 pairs of drivers; in 2 O1 locomotives, 5,000



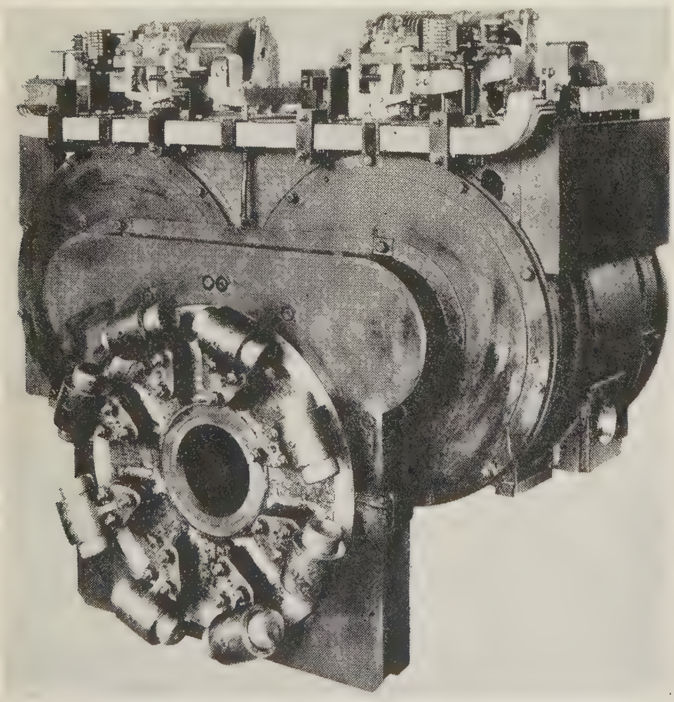
Speed-tractive effort characteristics of the P5 electric locomotive

hp. is available with 4 pairs of drivers; in a combination of an O1 and a P5 locomotive, 6,250 hp. is available; and in 2 P5 locomotives, 7,500 hp. Thus it is possible to increase locomotive capacity in steps of 1 pair of drivers, or 1,250 hp., and to select the proper unit for almost any weight or size of passenger train now used on this railroad or likely to be used in the near future.

While the freight locomotive's capacity cannot be increased in such steps, a careful study of freight service on the Pennsylvania has indicated that the unit selected is the best all-around one for handling freight trains on this system and that the steps in which the capacity can be increased are sufficiently flexible.

Unit Construction Used

Experience with construction and maintenance has indicated that in any class of electric locomotive, any part should be readily removable and replaceable, and that in so far as possible, all parts should be interchangeable between individual locomotives of the same class. The desirability of still further applying this principle between different classes of locomotives is evident. With the cooperation of the manufacturers, this has been accomplished in the P5 locomotive. Any unit or part, armature, motor, brushholder, transformer, or control unit, will fit and perform properly in any locomotive assembly regardless of the manufacture of other parts in that assembly. This principle has been developed further in the locomotive assemblies in that each complete



Twin motor assembly for P5 locomotive, pinion end, showing quill drive

assembly consists of 3 units, a chassis, an apparatus deck, and a cab.

Chassis. The chassis unit consists of the drivers, trucks, main frame, spring rigging, brake rigging, motors, flexible drives, main transformer, and train heating boiler, together with the necessary water and oil storage reservoirs, and air, oil, and water piping. Foundation for the chassis unit is a single steel casting into which are cast the oil and water reservoirs of the oil-fired steam boiler, as well as reservoirs for compressed air for the brake and control systems. At each end of this steel casting is a 4-wheel engine truck consisting of a single cast steel frame, a steel bolster casting, and the necessary spring and brake rigging.

All driving wheels, truck wheels, and motor armatures are mounted in anti-friction bearings. This type of bearing has been used extensively on this railroad for passenger car journals and for traction motor bearings; it is anticipated that by extending the use of these bearings to the driving wheel journals, truck wheel journals, and motor armatures, bearing trouble will be practically eliminated and locomotive maintenance expense materially decreased.

Apparatus Deck. This unit contains the main control groups, air compressor, miscellaneous apparatus, main wiring, and most of the control wiring. Foundation for this unit is a structural aluminum framework upon which the electrical equipment is assembled and wired. The assembly then is mounted as a unit directly on the chassis.

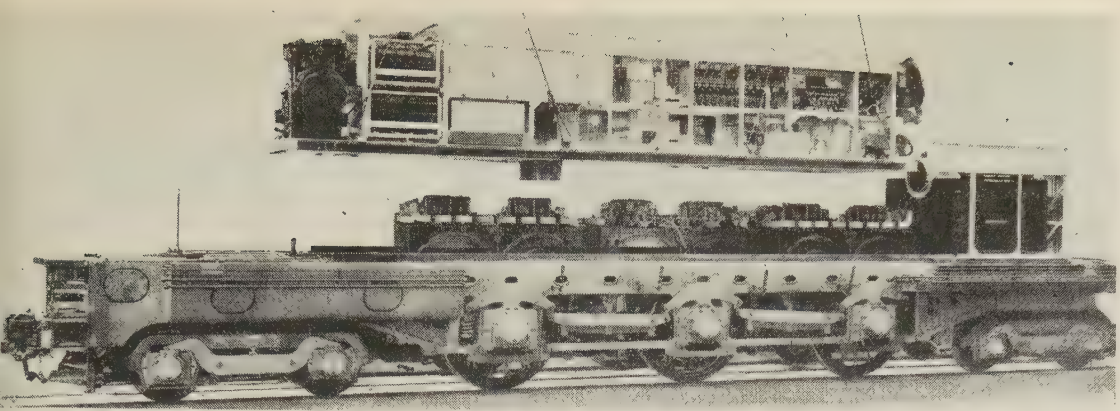
Cab. This unit forms a weatherproof housing for the locomotive crew and apparatus. The foundation is an aluminum structure divided into 3 compartments, a booth for the locomotive enginemen at either end, and a central compartment covering the apparatus deck. This unit houses also the heating boiler, main transformer, master controllers, the engineer's brake valves, some of the control wiring, and other miscellaneous accessories, and supports the pantographs, bell, and whistle. Louvers in the sides of the cab admit ventilating air to the motor and transformer blowers. The entire cab may be assembled as a unit, wired, and equipped with apparatus, then mounted directly on the chassis and over the apparatus deck.

Each of these 3 units of a locomotive may be assembled independently of the other, then assembled together into a complete locomotive. Parts such as a pair of drivers with motors and driving mechanism, a truck, or a control unit, may be removed and replaced with a minimum of disturbance to the rest of the locomotive.

Class O1 locomotive is in all respects similar to the Class P5 except that it has 2 driving axles instead of 3 and consequently is of smaller capacity. Equipment in the 2 locomotives is similar in every respect except that the transformer in the O1 is of smaller capacity.

Class L6 freight locomotive has 4 driving units with a 2-wheel truck at either end. Each driving unit carries but 1 motor armature with its frame, each motor being axle-borne, much in the manner used for years on trolley cars. The single motors of the L6 locomotives, however, are identical except for the frame, end housings, and pinion end bearings, with the motors of the twin units used in the passenger locomotives. In the L6 locomotive the cab and apparatus deck is of steel, as weight restrictions do not necessitate the use of aluminum.

Thus it may be seen that the P5 has 6 motor armatures, the O1, 4, and the L6, 4 motor armatures. All of these motor armatures are alike; also all twin frames are alike, as are all single frames. These motors have been rated nominally at a continuous output of 625 hp. per armature at the locomotive



Apparatus deck completely equipped being lowered upon the chassis of a P5 electric locomotive. Note unit construction. After the apparatus deck is secured to the chassis, the cab unit is added to complete the locomotive

driver rims; this gives a nominal continuous rating for the 3 classes of locomotives as shown in the accompanying tabulation.

Ratings of New Locomotives for Pennsylvania Railroad

Class	Hp.	Speed in Mi. per Hr.	Tractive Effort in Lb.
P5*	3,750	63.0	22,300
O1	2,500	63.0	14,900
L6†	2,500	37.8	24,800

* Geared for a maximum speed of 90 mi. per hr.
† Geared for a maximum speed of 54 mi. per hr.

With the foregoing general description of the locomotives in mind, it may be interesting to dwell upon some of the more important details.

Principal Parts Interchangeable

Interchangeability of parts has been referred to previously in this article, but the extent to which this interchangeability has been effected has not been treated in detail. It may be said that in the 3 classes of locomotives, the interchangeability of electrical parts is practically complete. The unit switches, master controllers, air compressors and motors, pantographs, blowers for motor ventilation, and relay systems, are identical. The preventive coils and transformers are identical on O1 and L6 locomotives, but are larger on the P5 locomotive because of the greater capacity required.

Although the assembled motors on the O1 and P5 locomotives are of the twin-armature frame-supported type and those on the L6 locomotives are of the conventional single-armature axle-supported type, the individual parts of the motors, including armatures and stators, are identical except that a larger pinion bearing is used in the axle supported motor to take care of the higher duty required by the freight gearing. The same stators may be pressed into or out of either type of frame.

Mechanical parts of the O1 and P5 locomotives are interchangeable to a large extent; driving wheel assemblies including bearings are the same as are the truck assemblies; also many parts of the spring and equalizing rigging and of the brake rigging are identical. Furthermore, many of the parts used to make up the apparatus decks and cab structures are the same.

Accessibility Aids Inspection and Repair

Accessibility of apparatus for inspection and repair also has been mentioned. This was the subject of continual study during progress of design, and every effort was made to insure that each piece of apparatus is not only readily accessible for inspection but also readily removable for repair. Thus a locomotive may have a defective piece of apparatus replaced and be returned to service in the minimum time. For this purpose hatches are provided in the cab roofs of all 3 classes of locomotives. Through these hatches any piece of apparatus inside the cab may be removed readily for repair or replacement.

A complete driving wheel assembly, including the motors, may be dropped from the frame in the repair shop and replaced in a relatively short time, thus making all electrical parts of the locomotive readily accessible and renewable either from above or below. In addition to this, each piece of apparatus inside the cab may be inspected readily from the interior; commutators and brushholders of the main motors may be inspected equally readily from the inspection pit.

Handling the large quantity of ventilating air necessary for cooling the motors and transformers was made the subject of detailed study. In the final design louvers are provided in the sides of the cabs that may be opened or closed, depending upon weather conditions. These louvers are so designed and constructed that screening devices may be applied should further operating experience indicate that such devices are necessary.

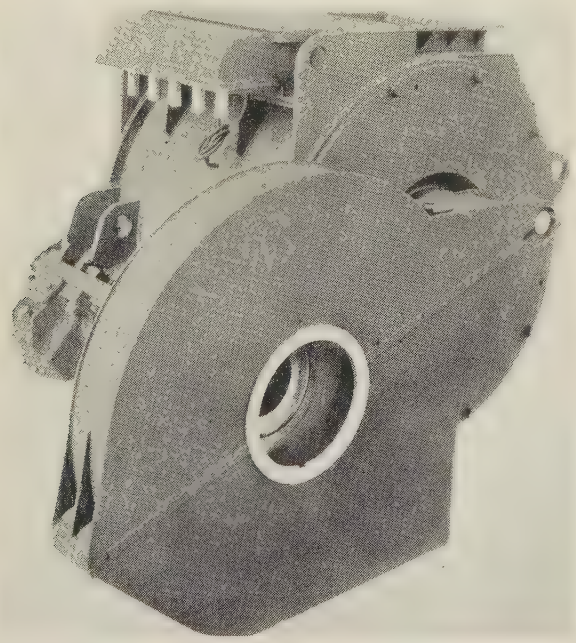
Type of Drive Used

The type of drive to be used between the pinion driven gear of the armature and the driving wheel has been the subject of much detailed study and analysis; several types of drives have been built and placed in service and on test. These tests still are proceeding, however, and final decision on this question will follow at a later date. The first 90 passenger locomotives built will be equipped with the cup drive shown in one of the accompanying illustrations; so far this drive has given excellent results in service. In the freight locomotives, the conventional arrangement of pinion and flexible gear used largely in multiple unit car construction and in previous

electric locomotives has been adapted to the tractive efforts and speeds of the freight locomotive.

Electrical Protection

For some years it has been the practise of the Pennsylvania Railroad to omit the use of a current rupturing device between the pantograph on an electric locomotive and the primary of the main transformer, and to substitute in its place a device known as a pantograph lowering relay. This relay is connected so as to use the substation circuit breakers to open high voltage short circuits, grounds, or overloads on the locomotive. In the P5, L6, and O1 locomotives this device has been supplemented by an automatic grounding device. Should a transformer short circuit or overload condition develop, this device will function automatically to ground the pantograph, thus opening the substation circuit breakers, after which the pantograph is lowered and locked automatically by the lowering relay.



Axle hung motor for L6 freight locomotive, showing gear case

Protection against motor overload is provided by relay devices, thus permitting the utilization of the maximum tractive effort made available by driving wheel adhesion, at the same time affording protection for the motors should this adhesion exceed normal values due to the application of sand or mishandling of the equipment. This relay protection also is interlinked with anti-wheelslip protection which insures driving wheel slippage being brought to the engineman's attention should he otherwise not detect it.

While it would be possible to enter into considerably more detail in regard to the various features of the design and equipment of these locomotives, such detailed treatment obviously would be beyond the intended scope of this article.

Wire Communication Aids Air Transportation

Through government aid, great progress has been made during recent years in reducing the hazards of bad weather to air transportation. Practically continuous reporting of meteorological information and weather forecasting along the principal airways is carried on with the aid of extensive teletypewriter network.

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RAPID DEVELOPMENT of air transportation in this country has continued through the past few years so that today established routes connect nearly all important cities. Route mileage of airways in the United States as shown in Fig. 1 totals over 30,000 miles. Regularly scheduled transport service is given on practically all of these routes; in addition, the routes are used to a considerable extent by military and private planes.

Statistics relating to service of air transport companies seem particularly significant: The United States Department of Commerce reported approximately 42,800,000 miles flown in passenger, mail, and express service on domestic scheduled lines in 1931, an increase of 35 per cent over the preceding year and more than a fourfold increase since 1928. In the same 3-year period passengers carried increased ninefold, reaching a total of about 470,000 in 1931. Along with this growth, safety has been increased as is indicated by the respective 1928 and 1931 reports of 250,000 and 750,000 miles flown per accident. Reasonably regularity of schedules on air transport lines also has been maintained, the ratio of miles actually flown to scheduled miles last year being of the order of 92 per cent.

Communication facilities have been an important contributing factor to all this development and improvement. It was recognized early that fast and reliable communication would be needed in connection with any extensive development of air transportation. Communication with planes in flight was an obvious requirement; this could be provided only by radio. For land service, however, experience has indicated that wire facilities best meet the general requirements. This article de-

Based upon "Wire Communication Aids to Air Transportation" (No. 32-82) presented at the A.I.E.E. Summer convention, Cleveland, Ohio, June 20–24, 1932.

cribes the wire communication facilities in general ise today, both by the government and by transport ompanies, as aids to air transportation.

Principal airways have been established largely hrough federal aid. In addition to marking and ighting airways the airways division of the United States Department of Commerce had provided up o April 1, 1932, 67 radiotelephone stations at approximately 200-mile intervals (see Fig. 1) to be ised for broadcasting weather reports and similar nformation to planes in flight and for transmitting lirective radio beacon signals for enabling planes o keep on the course. In conjunction with these ervices the airways division had contracted for 24-hour teletypewriter service along 13,000 miles of nain airways connecting some 250 stations, prinipally for the purpose of transmitting weather eports and to assist in dispatching the planes. All of these facilities have been made available vithout cost to aircraft operating companies and others using the airways.

In addition to the communication service conracted for by the government, approximately 5,000 niles of teletypewriter circuit are used daily in urnishing private wire communication service to everal transport companies for transmitting infornation pertaining to the operation of their own lines. Routes on which these facilities are furnished to he government and transport companies are indiated by heavy lines in Fig. 1.

When the first air mail service was established, radiotelegraph was introduced as a means of pointo-point communication along the New York-Chicago-San Francisco airway route. At each radio station meteorological data were collected from surrounding points by means of long distance telephone and telegraph; these data were exchanged periodically through the day with the other stations over the radiotelegraph. With a rapid expansion in air transport service foreseen it was apparent that a large increase in communication facilities would be needed. There was the definite requirement for radiotelephone communication with planes which would need several radio channels allotted to this service. Considering these factors and the geographic and other conditions, it seemed that regular point-to-point service served by radiotelegraph could be provided more satisfactorily in another way.

Arrangements were made in 1928 for teletypewriter communication at several points connecting radio stations with their local weather bureau offices in order to expedite the delivery of weather reports and other traffic handled by radiotelegraph. Shortly afterward, a teletypewriter system was installed on the New York-Cleveland route connecting the Department of Commerce and weather bureau stations at Hadley Field, Shelton, N. J., and Cleveland, Ohio, and several intermediate points. This type of service seemed ideally fitted for use in weather reporting and plane dispatching and has been extended not only to replace the service previously furnished by radiotelegraph, but also to provide for communication requirements of other routes.

Teletypewriter service offers the advantages of simultaneous communication with any desired num-

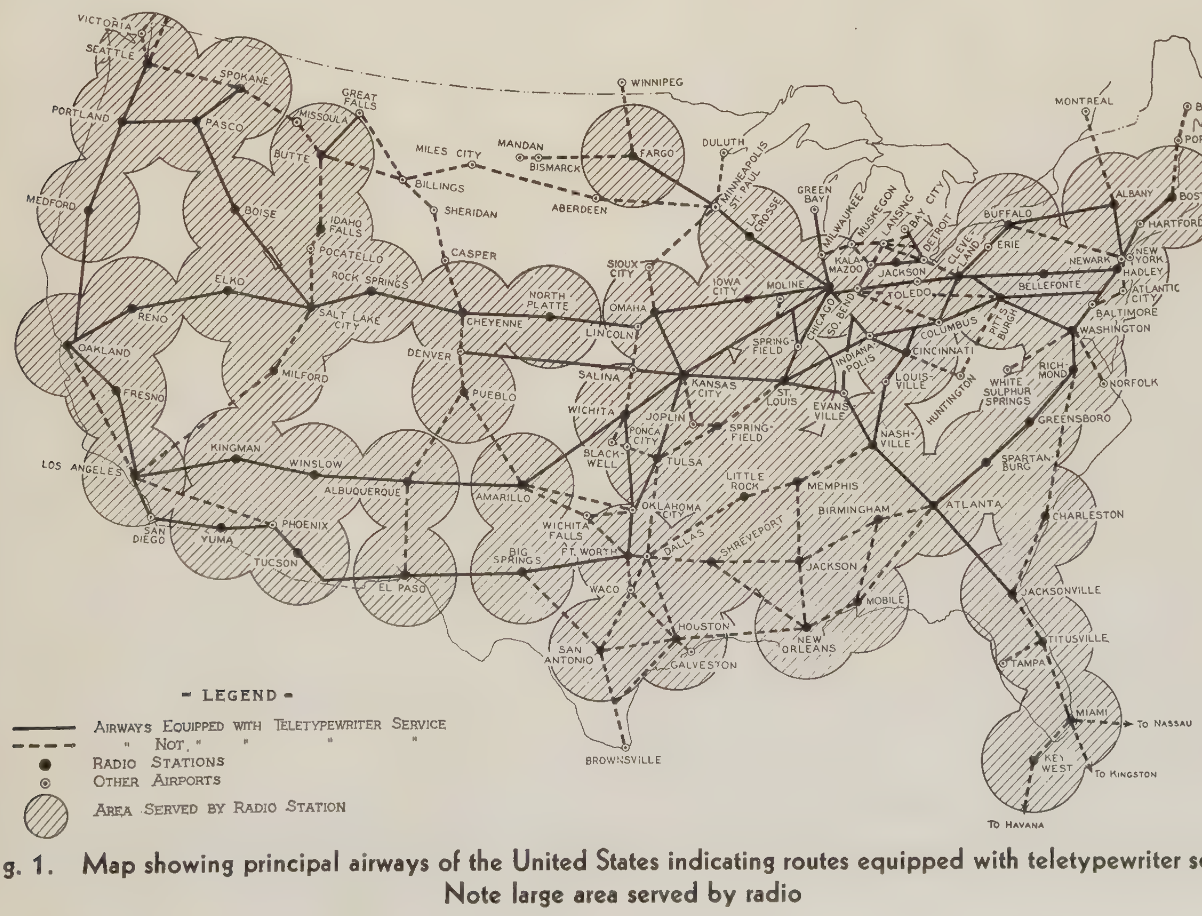

Fig. 1. Map showing principal airways of the United States indicating routes equipped with teletypewriter service. Note large area served by radio

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NK CV 0642ES
NK OVC LWR BRKN CLDS OCNL SPRKG ETD 6 HND 2 1/2 NE 8 42 40 3010
HW OVC LWR BRKN CLDS SPRKG HAZY 1 THSD 3 NE 5 42 3006
AL OVC LT RAIN LT FOG ETD 6 HND 2 E 10 41 3006
PL DENSE FOG LT RAIN ZERO ZERO ESE 15 37 3006
NU OVC LT RAIN HAZY ETD 1 THSD 3 E 12 41
SV OVC LT RAIN LT FOG ETD 12 HND 1 NE 9 43
WK DENSE FOG LT RAIN ZERO ZERO E 18 37 3004
BF OVC LT RAIN 8 HND 6 NE 6 43 43 2998
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Fig. 2. Portion of a typical weather sequence report as transmitted by teletypewriter

ber of stations, the communications being automatically recorded at each point. A message using code or abbreviations can be sent instantly without the necessity of calling or checking with the receiving stations, thus requiring the immediate attention of only the sending operator. Automatic recording reduces the possibility of human error and permits the most efficient use of operating personnel with resulting savings in labor. Furthermore, as contrasted with radio, this system utilizing wire transmission is not so subject to variations in meteorological conditions; it is thus more dependable, and has the further advantage that it can be extended readily to handle large volumes of business. This system also is well adapted to carrying on administrative and other work as well as to weather reporting and plane dispatching.

Transmission of Weather Reports

Notable progress has been made in reducing the effect of weather hazards to air transportation, through the service rendered by the United States Department of Commerce and weather bureau in the collection and dissemination of weather reports, supplemented by other reports collected by individual transport companies from planes in flight. A system of practically continuous reporting and forecasting for areas along air routes has been developed, and general weather observations have been extended to include data of particular benefit to air navigation. The teletypewriter networks furnished to the Department of Commerce are devoted largely to this purpose; in conjunction with the department's radio telephone broadcasting service these networks provide the means for furnishing to pilots information relating to existing conditions and forecasts for both general and local areas.

Twelve selected weather bureau airport stations located at strategic points in the country's airway network prepare summaries of weather conditions in their own areas and make area forecasts every 3 hours based upon data collected over the Department of Commerce circuits from connected airway stations, and over commercial telegraph lines from other reporting points. These summaries and forecasts then are transmitted over the teletypewriter circuits and made available to all airway stations.

While the forecasts include predictions as to storm developments or movements, conditions in specific

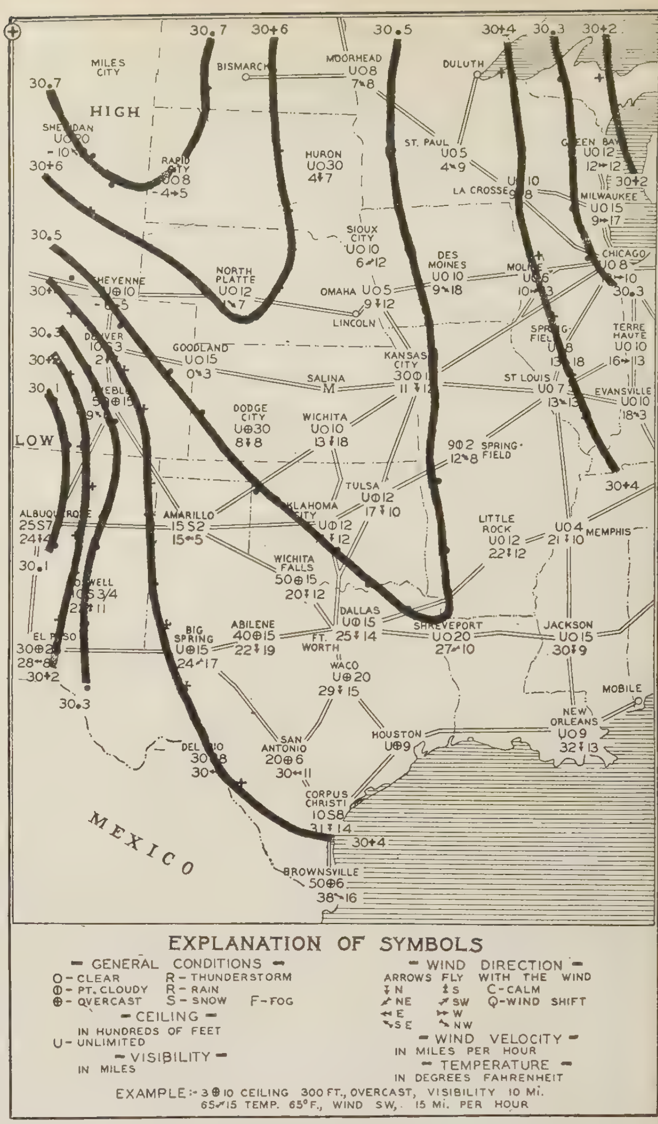

Fig. 3. Specimen weather map transmitted from 1 of the larger airports. A page teletypewriter with special characters is used for this purpose

localities often are likely to change rapidly; hence to keep pilots continuously advised of conditions likely to be encountered, it has been necessary to provide additional hourly reports along the air routes. Consequently, the airway keepers and weather bureau observers at the various teletypewriter stations make local observations of general weather conditions, ceiling height, visibility, wind direction and velocity, temperature, and barometric pressure, every hour. These data then are sent by the teletypewriter and automatically recorded at all points on the circuit in accordance with a predetermined schedule, which is coordinated with the broadcast schedule of radio stations. Since pilots will tune in on particular stations at definite times, it is important that the schedule be adhered to closely.

Fig. 2 shows a portion of an actual tape record of an hourly report along the Newark-Cleveland route. For convenience the tape has been cut to show 1 station report on each line. First, the starting time, 0642 E. S., which is 6.42 a.m. Eastern Standard

time, is shown. This is followed by a report of observations from each station given in sequence. The time of actual transmission for all 14 stations, Newark to Cleveland, would be about 4 min. and at 6.50 a.m. the reports would be broadcast as scheduled from the radio stations on that route.

Based upon the information obtained through the sequence collections, the airway weather reporting stations retransmit, generally by teletypewriter, hourly weather reports to the various airway operating companies' offices in that vicinity where the information is posted for convenience to pilots. An experimental service involving the transmission of weather summaries in map form was tried out recently at Kansas City, Chicago, Cleveland, Newark, and Washington. A separate circuit equipped with page teletypewriters at each of these points was provided for this purpose. The weather maps were prepared at Kansas City and Cleveland every 3 hours and then transmitted over this circuit. A typical map transmitted from Kansas City is shown in Fig. 3. The map data are sent in sequence from the 2 transmitting stations; after they have been recorded on the map forms at the receiving station several duplicate copies can be run off immediately and the 2 maps fitted together if desired. The maps then are available to pilots at each of the respective airports.

Complete reports of weather generally are maintained by transport companies in dispatching offices. On some lines 2-way short-wave radiotelephone equipment has been provided for communicating with planes, periodic contact being maintained during flight. In this way pilots report their positions directly to dispatchers; in addition supplementary weather data usually are exchanged, particularly with respect to local ceiling heights and conditions in the upper air strata.

Plane Dispatching and Other Service

Teletypewriter circuits furnished to air transport companies are used principally for dispatching planes and handling the many traffic matters usual to this type of service. Plane movements including reports of position in flight are transmitted over the teletypewriter system and recorded at various offices,

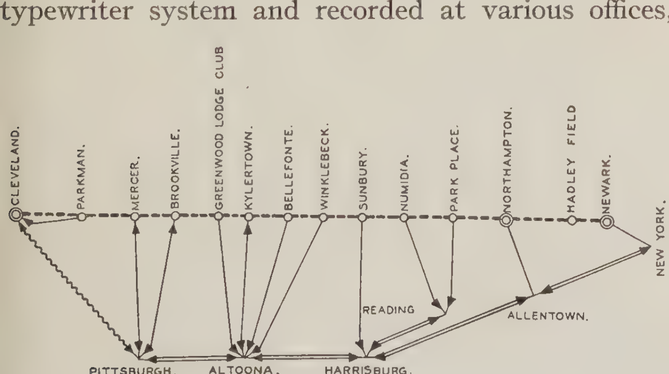

Fig. 4. A typical teletypewriter circuit for airway service

Intermediate airway stations often are situated some distance from main communication lines. A total of 846 miles of line thus is required to serve this 400-mile airway

the reports of positions in many cases being given by pilots over short-wave radiotelephone where this type of equipment has been provided.

To facilitate position reporting some of the companies have superimposed a system of rectangular coordinates over a map of the course cutting the territory into squares or rectangles 10 to 20 miles on a side. The coordinates are numbered so that the pilots and dispatchers can establish readily the location of the plane. Dispatchers generally maintain a typewritten, chronological log of position reports from each plane in the air. Bulletin boards also are used, marked with stations along the route and with spaces for filling in data such as plane number and license, name of pilot, time of arrival and departure at each station, and final destination.

On large lines a great deal of information is required to be transmitted in connection with the handling of traffic. Usually this consists of data concerning reservations, number of passengers and amount of mail and express carried, connections to be made, and arrangements at terminals. Supplementary instructions to pilots and many administrative matters requiring prompt handling also are transmitted.

Although airways teletypewriter circuits furnished to the Department of Commerce are used mostly for handling weather reports, considerable information also is transmitted relating to departure and arrival of planes and the positions of planes in flight. The Department of Commerce upon request will send over its teletypewriter system the license number of a plane, the station from which the plane is departing, its time of departure, and its destination, to stations along the route of the flight. Personnel of stations on this route knowing approximately the time due, then watch for the plane and record the actual time it passes so that other stations may be informed.

Teletypewriter Circuit Layout

Teletypewriter networks furnished by the Bell system for service along airways are composed of some 30 separate circuits. Circuit mileage of the longest is about 2,000 miles and of the shortest, 200 miles. The longer circuits generally connect 15 to 20 intermediate stations. Since airways naturally follow direct air lines the intermediate airway stations often are situated at points somewhat distant from main communication lines. (See Fig. 4.) At the larger airports such as Newark and Cleveland, local teletypewriter circuits also are provided to connect the Department of Commerce station with the offices of the various transport companies, the post office, and the weather bureau. Automatic transmission equipment is provided so that information received on 1 circuit can be retransmitted over 1 or more circuits as desired. Cable circuits, being less susceptible to interference and storm trouble than open wire circuits, where available have been used generally for establishing teletypewriter circuits furnished both to the Department of Commerce and to the transport companies. At present, over one-third of the mileage of these circuits is in

cable. Facilities on alternate routes are available to be substituted for the regular circuit in the event circuit trouble develops.

Teletypewriter Equipment

Theory of teletypewriter operation has been described in other papers and hence will not be reviewed here. Tape and page type sending and receiving teletypewriters commonly used in this country are also used in airways service. Tape machines are particularly suited for this purpose since messages are usually short, and weather reports from the various stations can be conveniently posted by cutting and pasting the tape as desired. In addition to the ordinary sending and receiving machines, however, supplementary apparatus units may be used so that operators can work at maximum efficiency and the line circuit can be used to its maximum capacity. These units are the perforator, the tape transmitter, and the reperforator.

Fig. 5. A typical airport teletypewriter installation

The perforator is associated with a keyboard and perforates a tape with from 1 to 5 perforations for each key struck; the tape then is run through a tape transmitter which automatically sends electrical impulses to the circuit corresponding to the perforations in the tape and identical to those that would have been sent from the keyboard sending. Use of the perforator and tape transmitter permits the circuit to be operated at its maximum speed at all times and permits the operator to work in spurts and rest or do other work while the accumulated tape is running through the transmitter. Also the same tape can be run through several tape transmitters and thus can be used for sending the message over several circuits.

The reperforator is a receiving device which records the message on a perforated tape similar to that produced by a perforator unit. This permits storing a received message for immediate or subsequent retransmission to other circuits without retyping it.

The smaller teletypewriter stations of the Department of Commerce and those of the various transport companies generally are provided with one or two teletypewriters. At the larger stations of the Department of Commerce a special arrangement of equipment has been provided to permit efficient operation of the circuits from the standpoints of requiring the fewest operators and of obtaining rapid retransmission of messages received on 1 circuit to 1 or more of the other circuits, as required. A view of a typical installation is given in Fig. 5. The apparatus is mounted on tables specially designed for the purpose; these tables usually are arranged on the floor in the shape of a "U," the units facing inward so that the operators work inside the "U."

The arrangement of equipment generally permits 1 operator to attend all of the circuits. The teletypewriters are all installed in a fairly small space, which permits 1 man to observe the incoming messages, and to operate the control boards, to start and stop the proper transmitter, and to relay messages as required.

Radio Interference

Establishment of teletypewriter stations along airways brought about the installation of teletypewriter equipment in the same room with, or in close proximity to, short-wave radio receivers; this introduced a problem in specific cases of radio interference caused by teletypewriter operation.

Remedial measures have been adopted effectively to reduce this interference and consist of the use of synchronous motors, rectifiers, and specially designed filters, together with the locating of the apparatus and wiring in such a way as to effect a minimum coupling between the teletypewriter and its associated loop, and the radio antenna system.

Conclusion

History of air transportation in the past few years indicates that continued growth may be expected, particularly as hazards to flying are mitigated and as safety and dependability are recognized by the public. The government is continuing the extension of airways, weather reporting, and other services; and air transport companies are progressing in the development of transport business.

Fast and reliable communication service has proved to be the backbone of weather and position reporting, and has been a valuable aid in the handling of traffic and other matters relating to air transportation. Teletypewriter circuits used for land service have been found particularly suited to meeting the various requirements involving simultaneous communication with many stations at remote distances. Other wire communication services such as long distance telephone and commercial telegraph also have aided, particularly in reaching points not served by teletypewriter circuits. It is expected that wire communication service will continue to be used extensively in connection with air transportation, and will be of considerable aid in its future development.

Stray Load Losses of a 55,000-Kva. Generator

Calorimeter tests on a 55,000-kva. hydroelectric generator show that the difference between stray load losses measured under load conditions and those measured under short-circuit conditions is slight. The method used by the authors is said to be applicable in general to all large units where an enclosed system of ventilation is used.

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IN ACCORDANCE with the A.I.E.E. standards, stray load losses of synchronous machines are determined with low excitation and with the machines short-circuited. There is still some question, however, as to whether this gives a true measure of the stray load losses under load conditions. In order to obtain a comparison between these losses on short circuit and under rated load, a series of thermal or calorimeter tests were made on one of the hydroelectric generators at the Queenston station of the Hydro-Electric Power Commission of Ontario, Canada. The machine tested is the last one installed and is rated as follows: 55,000 kva., 80 per cent power factor, 12,000 volts, three phase, 25 cycles, 187.5 r.p.m. The results showed but little difference between the losses measured on short circuit and those measured at rated load, the latter being slightly larger.

Method of Testing

In general the method followed in making the tests was to operate the unit under several different conditions until the temperature of the cooling air, stator iron and stator copper became constant in each case; great care was taken to measure these quantities accurately, especially the temperature of cooling air. As the accuracy of these tests depends upon the accurate measurement of ingoing and outgoing air temperatures, high grade thermometers calibrated and graduated to 0.2 deg. cent. were used. For measuring the temperature of the outgoing air from the generator, ten of the thermometers were placed at the point where this air enters the cooler; ten thermometers also were used to ascertain the temperature of the air at the point where it leaves the cooler. Other thermometers were used to measure the temperature of the stator iron, the steel wall of the chamber enclosing the unit, the air outside this chamber, and the inlet air to the unit. To determine the temperature of the stator copper, thermocouples placed in the stator slots were used. Electrical readings of current, voltage, and power were taken with portable meters of good accuracy.

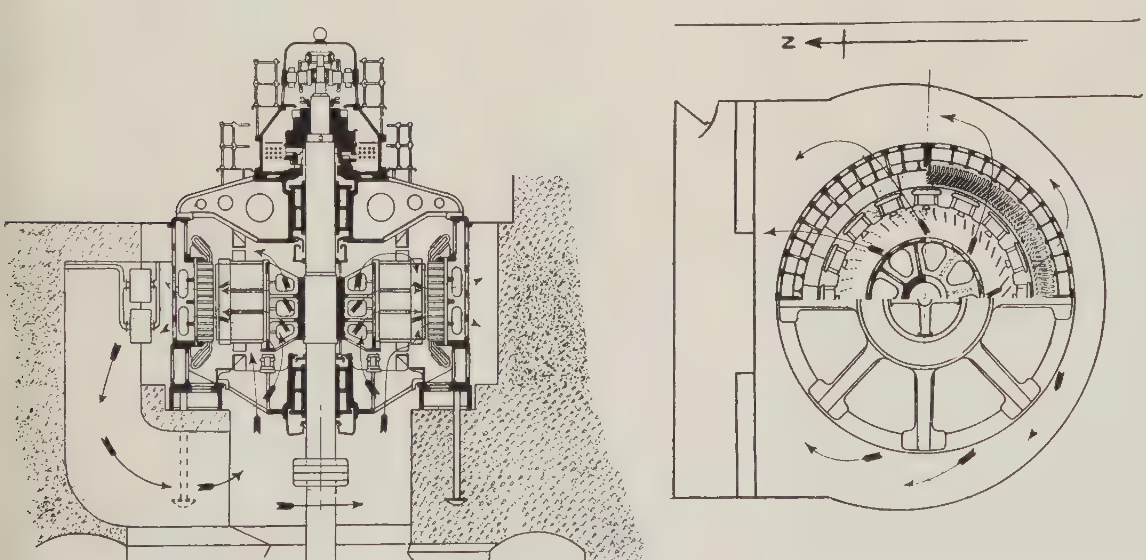

Fig. 1. Cross-section of 55,000-kva. generator for which stray load losses were determined; note completely closed ventilation system

Four different tests were made as outlined in the following paragraphs:

Test No. 1—Windage Loss

For this test the unit was operated for $20^1/_2$ hr. without excitation, starting with the machine hot. Temperature readings were taken during the first part of the run for a period of 5 hr.; at the end of

Based upon "Calorimeter Measurement of Stray-Load Losses of 55,000-Kva. Generator Having Enclosed System of Ventilation" (No. 31-126) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., Aug. 25–28, 1931.

the run two additional readings were taken, these giving the temperature rise due to the windage loss.

Test No. 2—Core Loss

For this test the unit was operated at synchronous speed without load, but with sufficient excitation to give 12 kv. at its terminals. This test extended over a period of 7 hr., temperature readings being taken throughout the run.

Test No. 3—Short-Circuit Test

On this test the unit was operated at its rated current of 2,650 amperes under three-phase short circuit. In this test it was found difficult to hold the stator current constant on the unit, the exciter being a direct-connected shunt-wound machine; thus small variations in speed caused corresponding variations in the excitation and in the short-circuit current. No special arrangements were made to control the excitation of the unit: had this been done perhaps the accuracy of the test could have been increased a small degree.

Test No. 4—Test at Rated Load

This test was made in two parts, (a) with a water rate of 500 gal. per min. through the coolers, and (b) with 400 gal. per min. through the coolers; both tests were made at approximately rated load. In order to complete the test in a minimum time the unit was operated for 8 hr. at approximately rated load, during which time no temperature readings were taken. The load then was set accurately as close to rated conditions as could be obtained and held, after which temperature readings were taken over a period of 3 hr. at $^1/_2$-hr. intervals. For the second portion of this test, the water rate was adjusted to 400 gal. per min., and temperature readings taken for an additional $4^1/_2$ hr. at $^1/_2$-hr. intervals.

Results and Calculations

The results of the four tests are shown in Figs. 2 to 5, inclusive. Tests No. 2 and 4 are of particular interest. For Test No. 2, the results are quite consistent and indicate that the temperatures of the unit and the temperature rise of the air can be found accurately; however, the test must be continued long enough to allow the temperatures of all parts of the machine to reach a constant value. It may be noted that the temperature of ingoing air to the unit rises along with the temperature of the unit itself; also that the air, iron, and copper temperatures arrive at a constant condition at the same time.

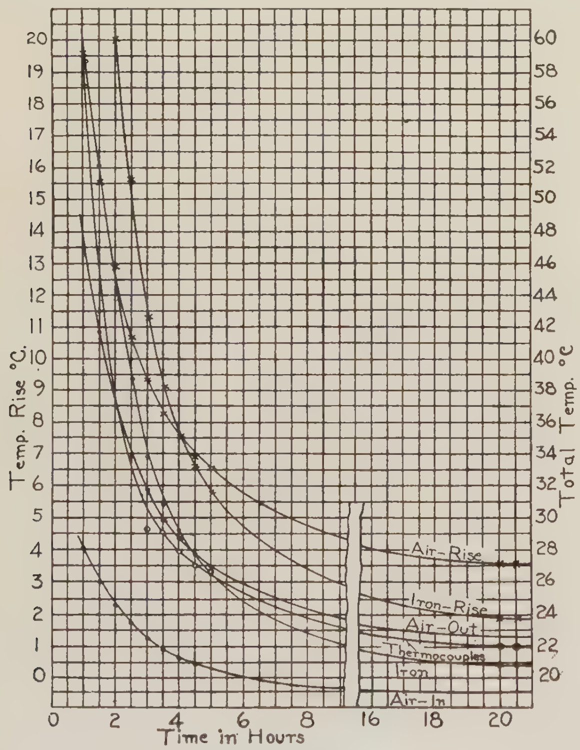

Fig. 2. Cooling curves for windage loss test (No. 1)

Test No. 4 indicates the accuracy with which the temperature measurements were made, and the effect of changing the water rate through the coolers. It may be noted from Fig. 5 that immediately following the adjustment of water rate, changes in temperature occurred which, although not great, were quite definite. The curves show also that a period of $4^1/_2$ hr. was required to bring the unit back to new constant temperatures differing from the previous ones by approximately $1^1/_2$ deg. The temperature rise of the air and of the iron, however, were the same values for both water rates.

Stray load losses are determined by the difference between the total losses as calculated from the temperature rise of the air and the known losses. The method of determining these losses from the test results is as follows: Temperature rise due to windage only is given by the results of Test No. 1, while Test No. 2 gives the rise due to windage and core loss;

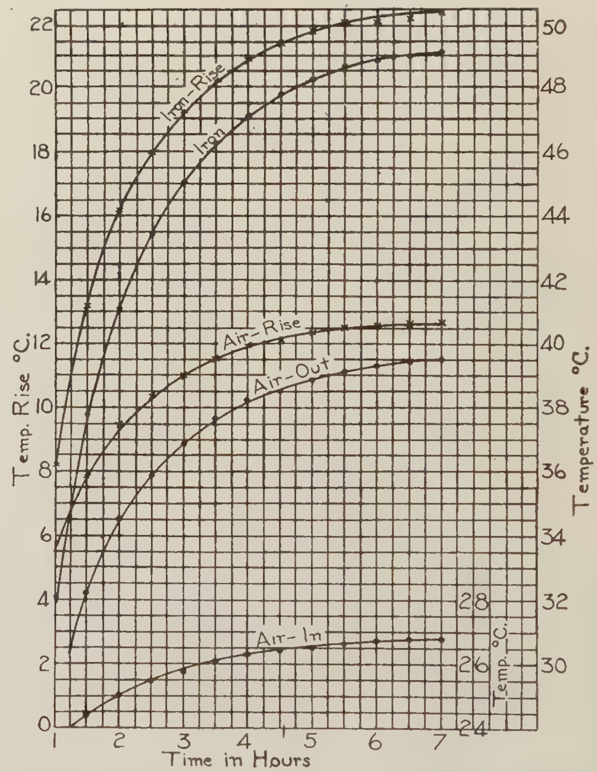

Fig. 3. Heating curves for core loss and windage test (No. 2)

Terminal potential....................	12,000 volts
Field current.........................	314 amperes
Collector ring potential...............	98 volts

the difference between these two values obviously gives the rise due to core loss only. Since the core loss is known from other tests, a constant K may be calculated giving the kilowatt loss per degree rise. With the aid of this constant, the loss for any other operating condition may be determined directly from the air rise.

These calculations involve the following tempera-

ture assumption: In an enclosed ventilating system where heat is being generated at a constant rate and the air is being cooled in coolers using a constant flow of water, the loss converted into heat is proportional to the temperature rise of the air, after all conditions have become constant. It is evident that the crux of the method is that all conditions must be constant. Among other things this requires that the humidity and barometric pressure must not change during any series of tests. If the pressure were to drop appreciably, the constant K would be affected, and it would be necessary to repeat the *windage* and the *windage and core loss* tests, in order to obtain reliable results; also, a constant K, determined under certain atmospheric conditions, obviously cannot be used with the results of tests under different atmospheric conditions.

Losses thus computed from these tests are shown in Table I. As a check on these results, losses computed from the heat absorbed by the cooling water are shown also in Table I. These figures are in remarkably close agreement when it is considered that the thermometers used in the cooling water were read to the nearest half degree only.

As a further refinement an attempt was made during the various tests to determine the amount of heat lost from the shell surrounding the generator. Temperatures of the shell and of the surrounding air were determined and the radiation loss calculated; these values are shown also in Table I as are recalculated values of the various losses taking into account these radiation losses. These latter calculations indicate that the radiation loss makes but a very small difference in the losses measured in this test, probably less than the experimental error associated with the test itself.

Stray power losses determined from the short-

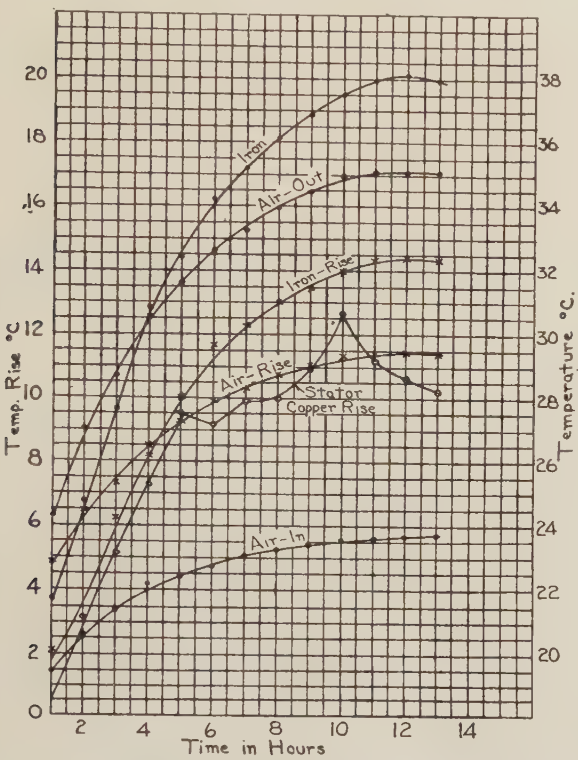

Fig. 4. Heating curves for short circuit tests (No. 3)

Armature current	2,650 amperes
Field current	320 amperes
Collector ring potential	98 volts

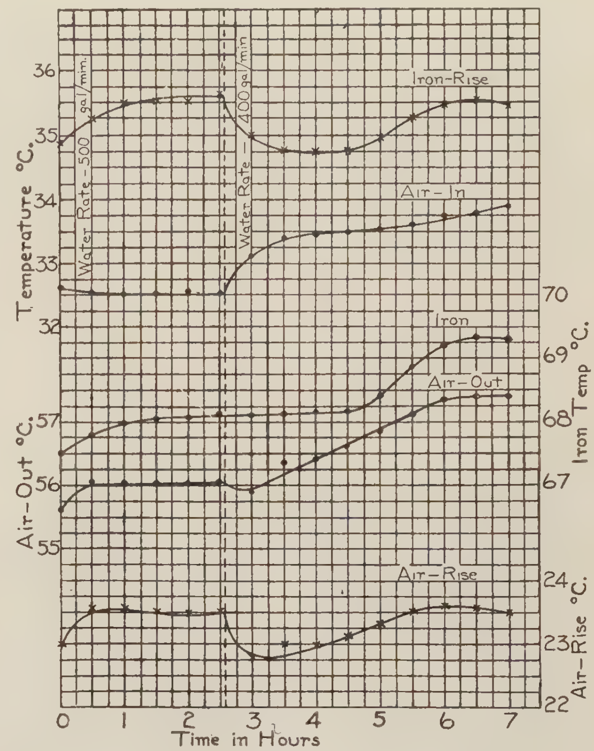

Fig. 5. Heating curves for rated load tests (No. 4)

	(a)	(b)
Water rate	500 gal. per min.	400 gal. per min.
Armature current	2,580 amperes	2,610 amperes
Terminal potential	12,070 volts	11,900 volts
Load	43,400 kw.	43,200 kw.
Field current	608 amperes	612 amperes
Collector ring potential	229 volts	234 volts

Table I—Losses Computed From Test Results

Test No.	Computed Losses in Watts: From Air Temperature Rise	*From Heat Absorbed by Cooling Water	Radiation Losses	Calculated Losses Allowing for Radiation
1	152	—	0	149
2	538	475	7	535
3	483	475	4	479
4(a)	990	1,030	16	987
(b)	990	1,010	16	987

* Thermometers accurate only to 0.5 deg. cent.

Table II—Comparative Stray Load Losses for Short-Circuit and Rated-Load Tests

Test No.	Computed From Air Temperature Rise (Watts)	Computed Losses With Allowance for Radiation (Watts)
3 (short circuit)	108	104
4 (rated load)	138	135

circuit (No. 3) and rated-load (No. 4) tests are shown for comparison in Table II; these are shown with and without provision for radiation losses.

Conclusions

Results of these tests indicate that for this particular type of unit, the stray load losses under short circuit and at rated load are approximately equal. The stray load losses are about 50 per cent of the stator copper loss at rated load. The results indicate also that if sufficient care is taken in measuring the temperatures, the stray load losses can be determined with fair accuracy on large units when an enclosed system of ventilation is used. The great drawback appears to be the time necessary to make a complete series of tests, although it is possible that a compromise test over a short period of time could be made and the final temperature rise of the air determined by calculation. The results obtained by Laffoon and Calvert (A.I.E.E. Trans., v. 46, 1927, p. 84–98) from calorimeter tests on turbine-generators agree with the results of these tests in that the stray load losses under load conditions are shown to be slightly higher than under short-circuit conditions. A logical conclusion seems to be then that if an accurate determination of the losses is required, a test under load conditions is justified; but for most purposes, a test under short-circuit conditions seems to be sufficient.

Characteristics of a Mercury Vapor Tube

Results of an investigation of the grid and plate currents in a grid-controlled mercury-vapor tube show that the direction of grid current in these tubes depends not only upon the instantaneous polarity of the grid, but also upon the magnitude of both the grid voltage and the plate current. It is shown also that inverse plate current flows whenever grid current is flowing during the negative half cycle of plate voltage.

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INCREASING use of grid-controlled mercury-vapor tubes for regulation, control, and rectification, makes desirable a study of certain characteristics of these valves which, judging from the literature available, have not as yet received the attention they deserve. The behavior of plate and grid currents, especially the latter, in some instances may inhibit the proper functioning of the tube and cause it to fail to play its proper rôle in the circuit.

One of the few investigators who has published his findings on the subject is Nottingham (*Journal*, Franklin Institute, v. 212, 1931, p. 271) who studied the grid and plate currents of these tubes chiefly under conditions prior to discharge. He found, as might be expected, that before the cathode-to-anode discharge takes place, the tube behaved as a gaseous triode. From preliminary experiments it became evident that some interesting studies were possible by investigating the plate and grid currents under various conditions of discharge. Accordingly, a series of tests was conducted using a typical mercury vapor tube of this type; the results point to the following conclusions:

1. The instantaneous direction of current flow in the grid circuit of a grid-controlled mercury-vapor tube depends not only upon the instantaneous polarity of the grid with respect to the cathode, but also upon the magnitude of the effective grid potential and upon the plate current.

2. The grid current may consist of positive loops only, of positive and negative loops of varying areas or equal areas, and of negative loops only, depending upon (*a*) the magnitude of the effective grid potential which determines whether or not the grid is able to repel positive ions when it is instantaneously positive, and electrons when it is instantaneously negative; and (*b*) the magnitude of the plate current which determines the degree of ionization present.

3. A d'Arsonval meter cannot be used in the grid circuit to determine the value of grid current, since the grid current wave generally has both positive and negative loops; in the extreme case where these loops are equal, such a meter would indicate zero current, although there might be an alternating current of considerable magnitude flowing.

4. When the grid voltage lags the plate voltage, the positions of the positive and negative loops of grid current may be transposed by merely varying the grid voltage.

5. An inverse plate current of the order of milliamperes always is present when grid current is flowing concurrent with the negative half cycle of plate voltage. When the grid current during the negative half cycle of plate voltage is zero, the lag of deionization of the mercury vapor allows some ionization to be present when the plate voltage changes to negative, thereby yielding a minimum, but not zero, value of inverse plate current.

6. With constant average grid current, the inverse plate current varies approximately sinusoidally with the angular displacement between the grid and plate voltages.

7. Formation of the positive ion sheath that envelops the grid and causes cathode-to-anode discharge is inhibited at low alternating grid voltages, by electrons having sufficient kinetic energy to enter the grid when it is at an instantaneous negative potential. For consistent operation the grid voltage employed to initiate discharge should be several times the critical voltage of the tube.

Written especially for Electrical Engineering. *Not published in pamphlet form.*

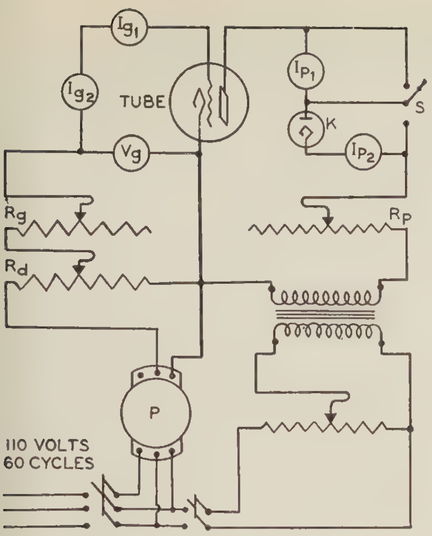

Fig. 1. Circuit diagram for determining characteristics of grid-controlled mercury-vapor tubes

Test Procedure

The tube used for this investigation was a General Electric type FG-29, air-cooled thyratron, intended for use as a controlled rectifier. The cathode of this tube is of the uni-potential coated type, the heater of which requires a current of 12 amperes; this was supplied from a special filament transformer. The tube is designed for a maximum forward and inverse potential of 3,500 volts, and a maximum average plate current of 12.5 amperes.

The circuit employed in the tests is shown in Fig. 1. The plate of the tube was energized from a 110/1,100-volt transformer. Voltage for the grid, variable in magnitude and phase, was obtained by means of a potential divider R_d which in turn was connected to one phase of a three-phase phase-shifter P. All tests were carried out at a frequency of 60 cycles and, unless otherwise stated, at an r.m.s. plate potential of 1,100 volts.

For measuring average values of the grid and plate currents d'Arsonval meters I_{g1} and I_{p1} were used; the effective value of the grid current was measured by a heater-thermocouple instrument I_{g2}. A dynamometer voltmeter V_g was connected directly between grid and cathode to measure the grid voltage. Inverse plate currents were measured by a d'Arsonval instrument I_{p2}. By throwing switch S to the upper position, the positive loop of plate current was blocked by tube K, a two-element high-vacuum rectifier. Resistances of the grid and plate circuits were varied by variable resistors R_g and R_p, respectively.

In the oscillograms reproduced it was thought more expedient to give the average and effective values of grid currents in lieu of placing current scales on the oscillograph traces themselves. Using a three-element oscillograph, two photographs for each condition were taken in order to include the four variables, grid voltage (V_g), grid current (I_g), plate voltage (V_p), and plate current (I_p); all four quantities have been shown together, however, by inking the wave of V_p on the oscillograms showing the other three values.

Grid Voltage in Phase With Plate Voltage

When the grid voltage is in phase with the plate voltage and is sufficiently high to repel electrons when the grid is instantaneously negative, the grid current wave consists of positive loops extending over the positive half cycle of the grid voltage wave. Under these conditions the grid current follows the shape that would be expected from a two-electrode mercury-vapor valve, but its wave is modified considerably with very low grid potentials. The oscillogram in Fig. 2 shows that with V_g = 5 volts (r.m.s.) the grid current is completely negative and exhibits two peaks. During the first portion of the positive half cycle of grid voltage, positive ions were able to enter the grid and thereby give rise to negative grid current; as the grid voltage reached its maximum positive value, the grid was able to repel the positive ions and attract electrons the net effect of which was to reduce the negative grid current to zero; however, as the grid voltage decreased from its maximum positive value, positive electrons again were able to enter the grid, thereby setting up another negative peak of grid current.

An increase of 1 volt in V_g removes the second negative loop of I_g shown in Fig. 2, and causes this portion of I_g to become positive; this is demonstrated in Fig. 3, the plate current and grid resistance being

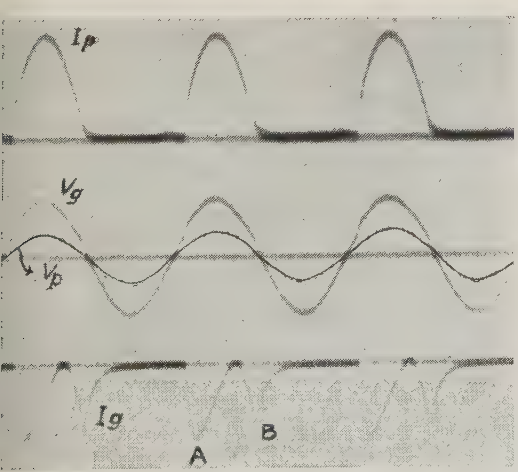

Fig. 2 (left)

V_g = 5 volts (r.m.s.)
I_g = 100 milliamperes (avg.)
R_g = 100 ohms
V_p = 1,100 volts (r.m.s.)
I_p = 1.2 amperes (avg.)

Fig. 3 (right)

V_g = 6 volts (r.m.s.)
I_g = 0 (avg.)
I_g = 3 milliamperes (r.m.s.)
R_g = 100 ohms
V_p = 1,100 volts (r.m.s.)
I_p = 1.2 amperes (avg.)

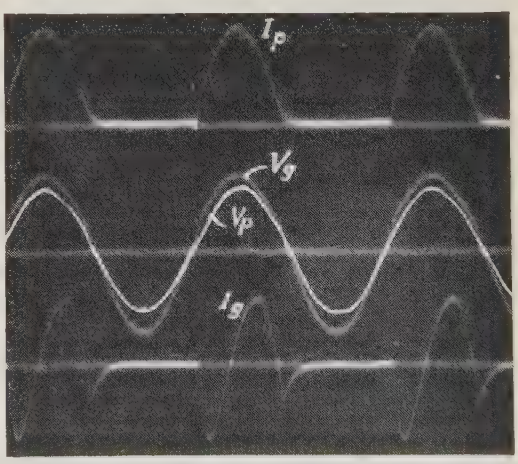

Fig. 2 (left) and 3 (right). Voltage and current relations with plate and grid voltages in phase

maintained at the same values as in Fig. 2. It may be observed that the increase in V_g from 5 to 6 volts enabled the grid to attract enough electrons, as V_g traversed its maximum values in its positive half cycle, to set up a positive loop of I_g, the area of which was equal to the area of the negative loop; thus the average grid current was zero, but the effective value was 3 milliamperes. As the grid voltage is increased beyond 6 volts, the negative loop of grid current decreases and the positive loop increases, until finally the grid current consists solely of positive loops.

From the foregoing it would be expected that if the average value of grid current were plotted against grid voltage, the curve first should have negative values, then reverse itself and later become positive. That this actually takes place may be seen from Fig. 4, where such curves have been drawn for three values of plate current with the plate and grid voltages in phase. From 0 to 3.75 volts the grid currents were too small to show on this plot, but their behavior in this region has been described by Nottingham (*loc. cit.*). The cathode-to-anode discharge took place at 3.75 volts. At this point, ionization caused by the flow of plate current furnished positive ions of sufficient velocity to enter the grid and make the areas of the negative loops exceed the area of the positive loop, as in Fig. 2.

For a given grid voltage the average value of the negative grid current depends upon the degree of ionization, i. e., upon the plate current; hence the 5-ampere curve shows the greatest negative value of average grid current, and the 10 milliampere curve, the smallest. As the grid voltage is increased, the positive loop of grid current also increases and the negative loops decrease, causing the curves to attain a negative maximum and return to zero. All three curves cross the zero axis in the region where the grid voltage equals from 6.5 to 7 volts; this is the region where the positive loop of grid current is equal to the negative loop as in Fig. 3. The positive loop of grid current increases also with ionization; hence above the zero axis the three curves lie above each other in the order of magnitude of their corresponding plate currents because the positive loop of grid current increases with plate current as well as with grid voltage; the negative loops finally disappear. Thus the curves cross as they intersect the zero axis and reverse in order.

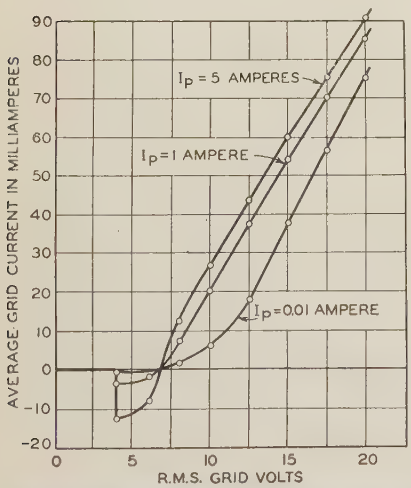

Fig. 4. Grid voltage-current relations with grid and plate voltages in phase

V_p = 1,100 volts
R_g = 100 ohms

Grid Voltage Leading Plate Voltage

When the grid voltage leads the plate voltage, the grid is positive before the tube begins to discharge. When the grid voltage becomes negative, the tube is discharging, positive ions are available, and hence the wave of grid current becomes negative. In Fig. 5 the grid voltage is shown leading the plate voltage by 90 deg. Grid current starts flowing when the grid becomes positive, then rises to a maximum, and falls to zero with the grid voltage. When the grid voltage becomes negative, the tube is still discharging and hence still generating positive ions. These positive ions enter the negative grid forming a negative loop of grid current which increases with the instantaneous value of grid voltage; this increase continues until the plate current is reduced to zero, when the source of positive ions disappears. At this point the negative grid current falls rapidly to zero, and remains so until the grid voltage becomes positive again in the following cycle. Thus, while the first half of the positive loop of grid current occurs before the tube discharges, the entire negative loop occurs while the plate current is flowing. From

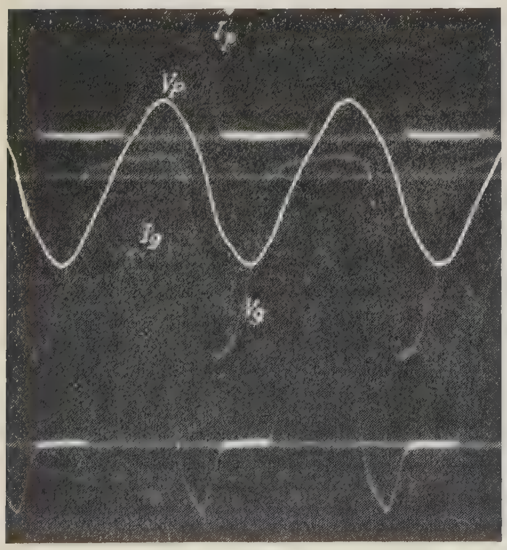

Fig. 5. (Left) Voltage and current relations with the grid voltage leading the plate voltage by 90 deg.

V_g = 40 volts (r.m.s.)
I_g = 275 milliamperes (avg.)
I_g = 600 milliamperes (r.m.s.)
R_g = 100 ohms
V_p = 1,100 volts (r.m.s.)
I_p = 4 amperes (avg.)

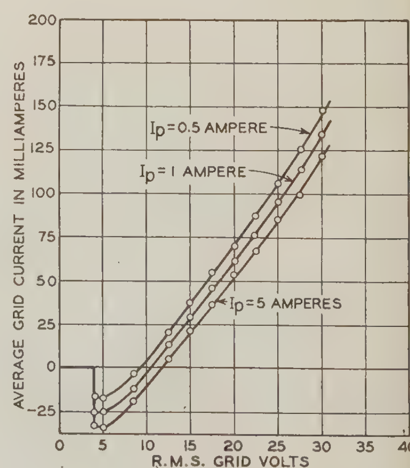

Fig. 6. (Right) Grid voltage-current relations with the grid voltage leading the plate voltage by 90 deg.

V_p = 1,100 volts; R_g = 100 ohms

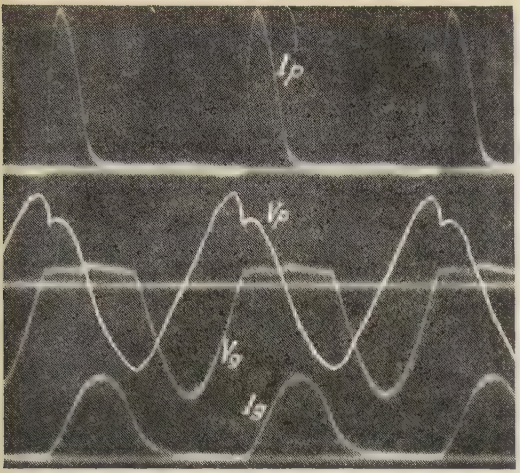

Fig. 7 (left)

V_g = 30 volts (r.m.s.)
I_g = 165 milliamperes (avg.)
I_g = 220 milliamperes (r.m.s.)
R_g = 100 ohms
V_p = 1,100 volts (r.m.s.)
I_p = 1.5 amperes (avg.)

Fig. 8 (right)

V_g = 6 volts (r.m.s.)
I_g = 6 milliamperes (avg.)
R_g = 100 ohms
V_p = 1,100 volts (r.m.s.)
I_p = 1.2 amperes (avg.)

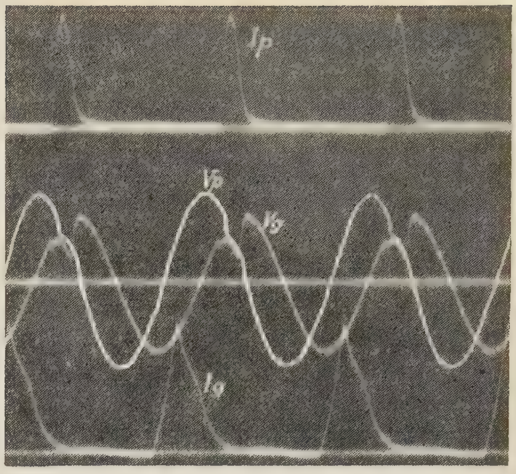

Fig. 7 (left) and 8 (right). Voltage and current relations with the grid voltage lagging the plate voltage by 90 deg.

this it would be expected that with a decrease in grid voltage the negative loop would grow faster than the positive loop.

If the grid voltage be reduced to small values, the negative loop of grid current decreases more slowly than the positive loop, and the average grid current becomes negative. Variation of the average grid current with grid voltage, with the grid voltage leading the plate voltage by 90 deg., is shown in Fig. 6. Shapes of the curves are similar to those obtained with grid and plate voltages in phase, with the exception that the curves do not cross each other and reverse their order as they intersect the zero axis (see Fig. 4). From 0 to 3.75 volts the grid currents were too small to plot, as in Fig. 4. At 3.75 volts, the tube discharged and the grid currents became negative, the negative values for a fixed grid voltage increasing with the plate current. This is due to the negative loop of grid current increasing with the increase in ionization afforded by the increase in plate current. As the grid voltage increases, the curves attain their negative maxima and return to zero in the interval where the grid voltage equals from 9 to 12 volts. Above the zero axis, the curves for the lower plate currents assume higher positions, i. e., for a fixed grid voltage the average value of grid current decreases with plate current; the loops of negative grid current increase with plate current. At the same time, a large portion of the positive grid current flow occurs before the tube discharges. The result of this is that with increase in plate current for a given grid voltage the negative portion of grid current grows more rapidly than the positive portion, and the average grid current decreases with an increase in plate current. For this reason the curves do not reverse their order as they cross the zero axis.

Grid Voltage Lagging Plate Voltage

Behavior of the grid current when the grid voltage lags the plate voltage by 90 deg. is shown in the two oscillograms reproduced as Figs. 7 and 8. In Fig. 7 V_g was maintained at 30 volts. During the negative loop of grid voltage, no plate current flows because no positive ions are present and the grid current is zero. When the grid becomes positive, a positive grid current begins to flow increasing to a maximum value, then decreasing gradually to zero after the grid voltage has become zero. The discharge has ceased since the plate voltage has become negative; thus there is no source of positive ions for the negative grid and accordingly the grid current remains at zero until the grid becomes positive in the next cycle.

If the grid voltage be reduced to a much lower value than in Fig. 7, the positive loop of grid current will be found to shift its position from the second quarter cycle (counting from the instant when the plate voltage becomes positive) to the first quarter cycle. An oscillogram for this condition is presented in Fig. 8, where V_g was reduced to 6 volts. Comparing Figs. 7 and 8, the positive loop of grid current apparently has shifted from the quarter-cycle during which the tube discharges, to the quarter-cycle of positive plate voltage during which there is no discharge. In Fig. 8, although the grid voltage is low, no electrons enter the grid by virtue of their velocities during the fourth quarter-cycle when the grid is negative, because of the negative potential of the plate. During the first quarter-cycle, however, the plate voltage is positive and electrons coming from the cathode are able to impinge upon the grid although the grid is at a negative potential with respect to the cathode; thus a positive loop of grid current is formed during the first quarter-cycle. The total current produced by electron emission from the cathode entering the grid is small compared with the ionization available for producing grid currents when the tube is discharging. Accordingly, the magnitude of the positive loop of grid current for a grid potential of 5 volts is small compared with that for a grid potential of 30 volts, the average grid currents in the two cases being 5 and 165 milliamperes, respectively.

Referring to Fig. 8 again, when the grid voltage becomes positive and discharge begins, the resultant ionization produces positive ions of sufficient velocity to enter the grid, although the grid is at a low positive potential and is receiving electrons from the filament. The net result is that the grid current is reduced to zero and remains so until the plate voltage becomes positive in the following cycle. If the

voltage of the grid was lowered still further, the grid current in the second quarter cycle would not only be reduced to zero, but would be depressed to a negative value by the positive ions generated by the plate current.

Inverse Plate Current

Whenever the grid voltage either lags or leads the plate voltage, grid current flows during part of the negative half cycle of the plate voltage; when the grid voltage leads the plate voltage, the initial portion of the grid current flow occurs when the plate voltage is negative; when the grid voltage lags the plate voltage, grid current is flowing when the plate voltage changes from positive to negative. Whenever grid current is flowing, positive ions are available because of ionization of the mercury vapor. Hence whenever grid current is concurrent with negative plate voltage a negative loop of plate current should be present. The oscillograms presented thus far show no negative loops of plate current because of the disparity in magnitudes between the positive loops and the negative loops, the latter of which have their origin in the comparatively small amount of ionization afforded by the grid current.

When the phase displacement between the plate and grid voltages is 175 deg., a positive loop of grid current flows when the plate voltage is negative; this condition is illustrated in Fig. 9 where the average value of plate current was reduced to 13 milliamperes by plate circuit resistance to bring out the negative loop more prominently. With fixed plate voltage, the magnitude of inverse plate current depends upon the magnitude of grid current flowing when the plate is negative. When the potential of the grid is sufficiently high to prevent electrons from impinging upon the grid when it is negative, and likewise to prevent positive ions from entering the grid when it is positive, the grid current follows the grid voltage with a certain lag. From this it follows that with a constant average grid current, maintained by adjustment of grid voltage, the variation of inverse plate current with phase displacement between grid and plate voltages should be approximately sinusoidal. In Fig. 10 are plotted values of negative plate current against angular displacement between grid and plate voltages, for three constant values of average grid current. These curves follow quite closely the form $A + B\cos(\theta-\alpha)$ where θ is the angular displacement between the grid and plate voltages, α is the angular displacement between the grid voltage and current, and A and B are constants. Sinusoidal variations computed on the basis of maximum values of the observed currents coincide with the experimental curves obtained, except for a short section of the curve for an average grid current of 0.2 ampere; that portion of the computed curve which deviates is shown by a broken line. Data for these curves were taken by throwing switch S in Fig. 1 to the upper position, thereby blocking the positive loops of plate current by tube K and reading the average values of inverse current on milliammeter I_{p2}. The plate potential was maintained at 1,100 volts (r.m.s.) and the plate circuit resistance when the inverse plate current was flowing was the plate resistance of tube K, a type KM-1 kenotron.

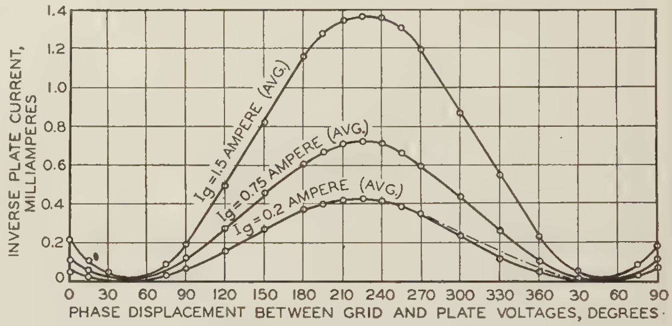

Fig. 10. Inverse plate current as a function of phase displacement between grid and plate voltages

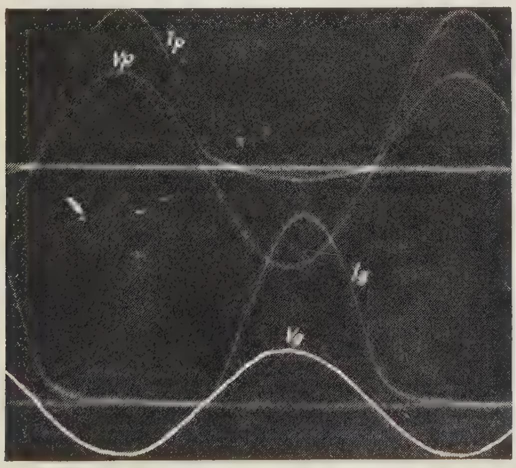

Fig. 9. Voltage and current relations with the grid voltage leading the plate voltage by 175 deg. Note inverse plate current

V_g = 60 volts (r.m.s.)
V_p = 1,100 volts (r.m.s.)
I_g = 790 milliamperes (avg.)
I_p = 17 milliamperes (avg.)
R_g = 50 ohms

The grid current in the inverse current tests lagged the grid voltage by approximately 40 deg.; from this it would be expected that the inverse plate current would be at its maximum value when the positive loop of grid current coincides with the negative loop of plate voltage, that is, at 180 deg. + 40 deg. This is seen to be the case in Fig. 10. In the same way the minimum value of inverse plate current is shifted from the 0-deg. point by the same angular displacement. There is no null value of inverse plate current because when the positive loop of grid current is contained wholly within the positive loop of plate voltage, the plate becomes negative before deionization is complete; hence there is a small source of positive ions which yields a minimum but not zero value of negative plate current at that point.

From the foregoing it may be seen that no matter what the phase displacement between the grid and

plate voltages may be, an inverse plate current always is present. Its minimum value is determined by the quantity of positive ions remaining, due to lag in deionization, when the plate potential reverses; its maximum value is determined by the magnitude of grid current flowing when the plate voltage is negative.

Two tubes of the same type were studied and only slight variations of magnitude in the phenomena described were observed. Because the number of tubes was limited to two, the characteristics presented are not set forth as average characteristics of grid-controlled mercury-vapor tubes, but merely as typical of this particular type of tube.

Insulator Performance Studied by Flashover Tests

Many factors affect the flashover characteristics of porcelain insulators; these characteristics in turn have a direct bearing upon insulator design and upon the choice of proper insulation for any particular purpose. In the following group of three articles by representatives of three of the leading insulator manufacturers, results of investigations made in this field by these manufacturers are given. In the past, many of the data for comparable insulators from different sources seemed conflicting. In these articles, however, reasonably careful study will reveal many points of agreement, when the results are reduced to a comparable basis. The first two articles deal with the effect of various factors on insulator sparkover characteristics; the third article deals with the flashover characteristics of suspension insulators, and also contains data relating to the cost and selection of economical suspension insulator assemblies.

I—Insulator Arcovers Versus Size and Humidity

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DATA covering the electrical characteristics of comparable insulators as received from different sources frequently are conflicting. In an attempt to clarify some aspects of this controversial subject, a study has been made to establish rules whereby such characteristics can be estimated from the dimensions of the insulators with a reasonable degree of certainty. Variations in the arcover potential of dry insulators due to the influence of humidity changes also are considered and approximate correction ratios given.

Conclusions of the study are based upon an extensive series of tests made in the high voltage laboratory of the Locke Insulator Corporation at Baltimore, Md. Throughout the tests all voltage measurements were made as prescribed in the A.I.E.E. Standards. All tests were made at a frequency of 60 cycles.

Suspension Insulators

Tests were made on suspension insulators of both the cemented and Hewlett types, with unit spacings of from $4^3/_4$ to 7 in. and with diameters ranging from 10 to 12 in. It was found that within these dimension limits the flashover voltages of all insulators when dry fell upon one curve when plotted against actual arcing distance, the shortest air path between

Based upon "Normal Frequency Arcover Values of Insulators as Affected by Size and Humidity" (No. 32-62) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

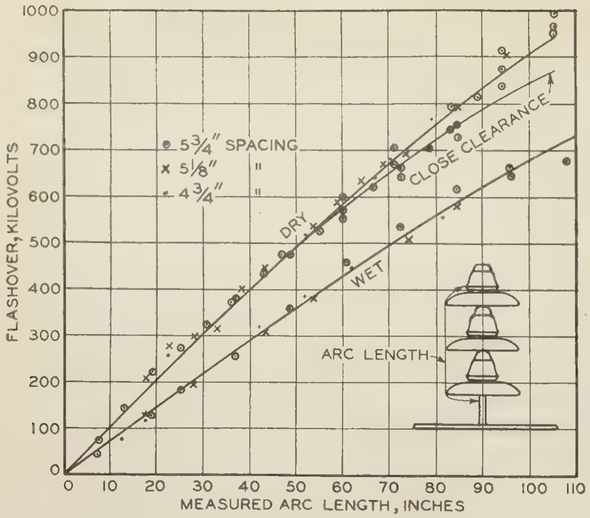
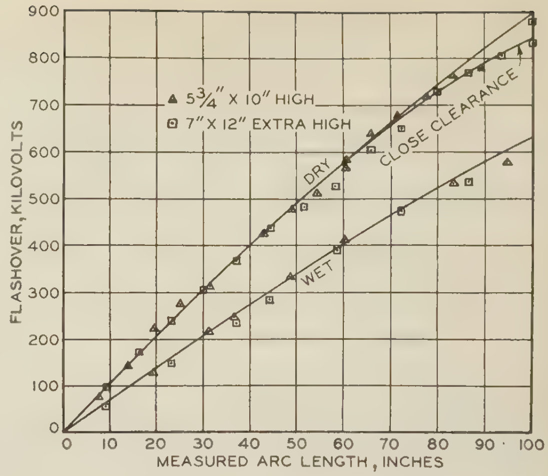


Fig. 1. (Left) Flashover characteristics of 10-in. standard-strength suspension insulators

Fig. 2. (Right) Flashover characteristics of high-strength insulators



electrodes. Flashover for voltages for wet insulators when so plotted showed some variation depending upon the design of the insulator. The curves of Figs. 1 and 2 show the dry and wet values for cemented type insulators plotted against actual arcing distance. Flashover voltages for dry insulators are affected by the proximity of grounded objects. This is shown by the double graph at the upper end of the dry curves, the upper graph being obtained with clearances at least twice the length of the insulator string.

For design purposes it is most usual to plot flashover voltages for wet insulators as a function of the wet striking distance or the summation of the air gap distances beneath the insulator, assuming that the wetted surfaces above are short-circuited out by the water film. A satisfactory check is so obtained as shown by Fig. 3. Expected arcover potentials for dry and wet suspension insulator assemblies are given in Figs. 4 and 5, plotted as a function of the number of units in the string, and calculated from Figs. 1 and 2.

Standard- and high-strength cemented insulators were tested also in the anchor position at an angle of about 10 deg. from the horizontal. Arcover voltages obtained for both dry and wet conditions are shown in Figs. 4 and 5 in comparison with corresponding values for the vertical assemblies. The "dry" arcover values are materially lower for the horizontal than for the vertical position; "wet" values, however, are much higher for the horizontal than for the vertical. This is because when the entire surface of the insulator is uniformly wetted, a better voltage division between insulator units is obtained with the resultant higher voltage necessary to cause breakdown. The "wet" values for the horizontal strings are actually equal to, and in some cases with long strings, higher than the "dry" values for the same position.

Most of the tests in the horizontal were made without a jumper loop under the string or a conductor at right angles to it. Insulators in the horizontal position with the conductor at right angles showed dry arcover potentials materially higher than without it, yet not equal to the values obtained for the vertical suspension insulators.

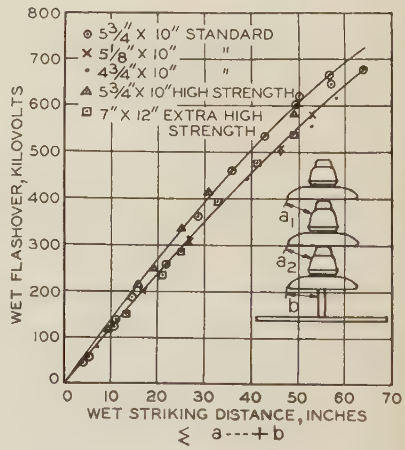


Fig. 3. Flashover characteristics of all-cemented suspension insulators when wet

Pin Insulators

Standard pin insulators show fairly uniform arcover voltages in proportion to the distance between electrodes as shown in Fig. 6. The small contact area of tie wires upon the porcelain causes heavy dielectric flux concentration on the tie wires, with resultant active corona streamer formation at voltages near arcover. Because of the erratic action of these streamers, observed data show the least uniformity of any of the types of insulator tested.

It is interesting to note that more consistent comparisons of data for wet pin insulators are obtained on the basis of *total* striking distance rather than *wet* striking distance. The low sparkover voltages for the small one-piece insulators when wet are due to the large proportion of wetted surface to total striking distance.

Outdoor Apparatus Insulators

Outdoor apparatus insulators are pin types modified by adding cemented-on caps for attachments. In comparison with pin types these insulators show less variation between individual observations. This is brought about by the greater contact area of the cap, which causes less flux concentration and less corona streamer formation at voltages below flashover.

In Fig. 7 are shown flashover voltages of single and multiple unit insulators when both dry and wet; in

both cases the results are plotted against actual arcing distance. As is shown, however, data for the wet condition are far more consistent when plotted against wet striking distance.

Equipment Bushings

Performance of solid porcelain equipment bushings (not oil filled) is shown in Fig. 8 for ratings from 7.5 to 69 kv. The field established about the bushing determines its arcover potential when dry. In tests of this nature it is important that the conductor be in place inside the insulator as it will be in service, since much higher values are obtained without it. When the bushings are wet the arcover potentials are the breakdown voltages for the water film on the surfaces; for the larger bushings the values are higher when the insulator is wet than when dry.

Humidity Effects

The effect of humidity upon the dry arcover voltages of insulators may be compared on several different bases as follows:

1. By a comparison of flashover values on the basis of per cent humidity. This is not satisfactory, for it alone does not account for the total quantity of water in the air.

2. By a comparison on the basis of absolute humidity or mass of water per unit of air volume. This method may be satisfactory, but does not account for the molecular activity of the water.

3. By a comparison of flashover on the basis of water vapor pressure in some convenient units such as inches of mercury in the barometric method. This accounts not only for the number of water molecules present, but for their velocity as well.

Throughout the common range of temperature the numerical difference between vapor pressure (expressed in manometric inches of mercury) and absolute humidity (expressed in grains per cubic foot) is so slight as to make no practical difference as to which is used as the basis. Water vapor pressure as the standard is recommended by the A.I.E.E. Standards (41-100); hence all observations in this portion of the investigation have been compared upon this basis.

Effects of humidity upon the dry flashover of standard suspension insulators are shown in Fig. 9. By plotting on semi-logarithmic paper equal ordinate distances give equal percentage variations. Thus it is easy to compare percentage corrections for different strings and percentage variations from the average of individual observations. The slope of all these average graphs is practically the same. When referred to 100 per cent at the standard water vapor pressure, 0.608 in. of mercury the correction at 0.2 in. of mercury is −8 per cent; the correction factor, therefore,

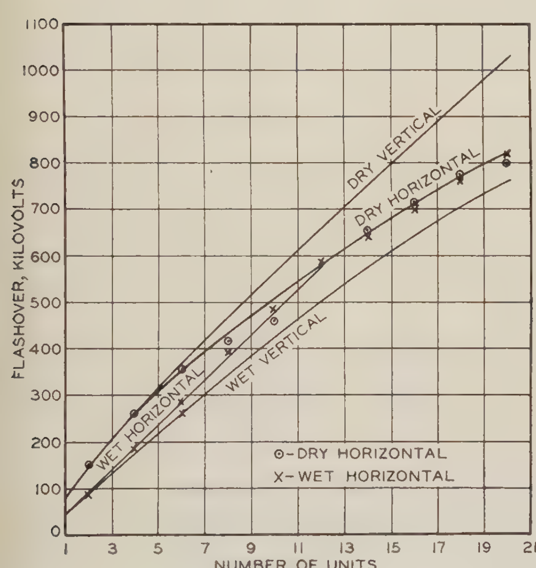
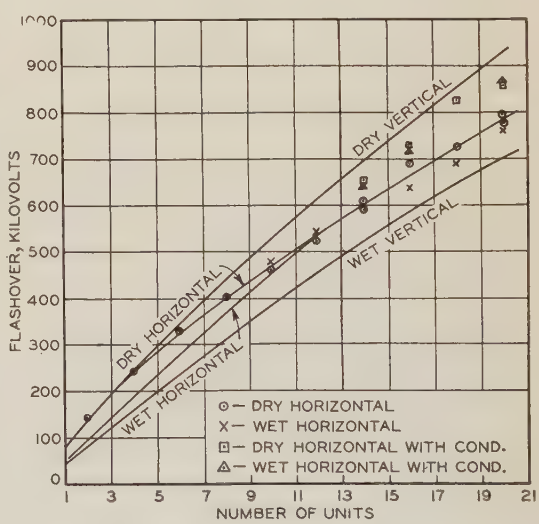


Fig. 4. (Left) Flashover characteristics of insulator assemblies made up of 10-in. standard-strength units, spaced 5¾ in. apart

Fig. 5. (Right) Flashover characteristics of suspension insulator assemblies made up of 10-in. standard-strength units, spaced 5⅛ in.



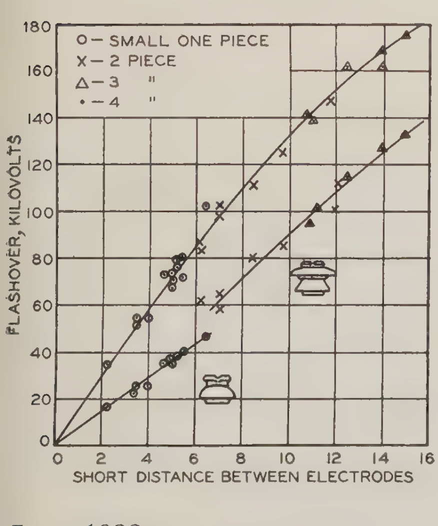
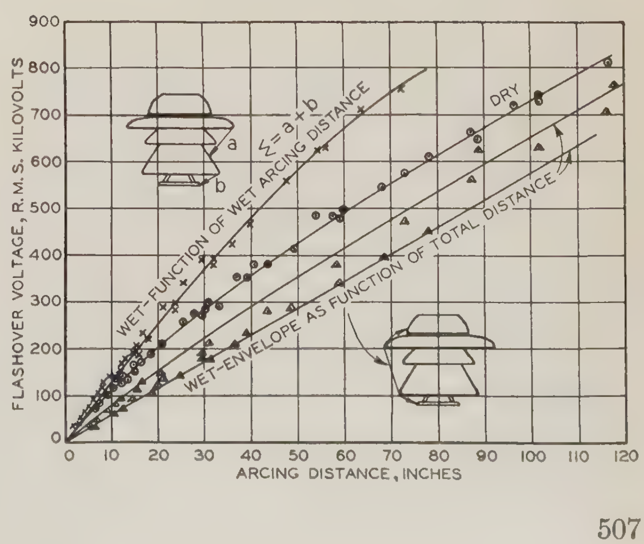


Fig. 6. (Left) Flashover characteristics of pin insulators

Fig. 7. (Right) Flashover characteristics of outdoor apparatus insulators



is approximately 2 per cent for each 0.1 in. of mercury variation in water vapor pressure.

As may be seen from Fig. 9, the points of observation would be inclosed within an envelope of plus and minus 5 per cent from the curve of averages. It follows, therefore, that even with the correction for humidity a variation of plus or minus 5 per cent in flashover values of suspension insulators must be expected.

Effects of humidity on flashovers of typical pin insulators are shown in Fig. 10. Only one insulator of each type was tested; thus the variations shown are not due to manufacturing variations in different insulators. The individual observations may be seen to lie within an envelope of plus or minus 6 per cent, the broadest variation of any type of insulator tested. The variation in flashover of all insulators between vapor pressures of 0.2 and 0.608 in. of mercury is about 12 per cent. Frequently in testing at standard temperature with a relative humidity above 65 per cent, erratic performance and marked fall in flashover voltage was observed. A typical example of this is shown for the 27-kv. insulator. Such behavior is believed to be due to the formation of an invisible water film upon the surface of the insulator at these higher humidities.

Tests were made also to determine the effect of humidity upon typical outdoor apparatus insulators. Compared with the pin types these insulators showed much more stable performance; this is due to absence of corona streamers as already discussed. Variation from the average curve is not over plus or minus 5 per cent, and the correction for humidity is 8 per cent between vapor pressures of 0.2 and 0.608 in. of mercury, the same as for suspension insulators, but less than for pin types.

Performance of porcelain equipment bushings with varying humidity also was investigated. The humidity correction for these bushings was found to be the same as for all others except the pin types.

Effect of Surface Conditions

In an effort to determine how the above rules for insulator flashover might be affected by surface conditions, representative insulators were exposed for a period of several months above the smoke boxes of a battery of beehive kilns. At the expiration of this period the surfaces of these insulators were thoroughly covered with a dirt deposit consisting largely of carbonaceous material mixed with a certain amount of clay dust and ordinary floor dirt. Due to the baking action of the heat from the kilns the coating was rather hard. Other insulators of exactly the same type were thoroughly coated with a salt crust by spraying them with a concentrated salt solution and allowing them to dry.

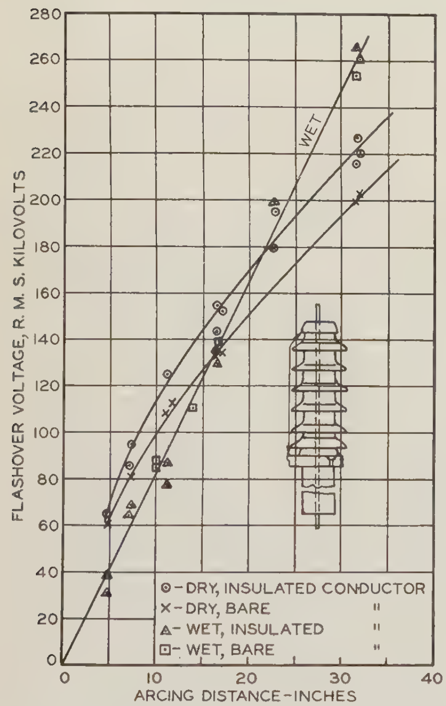


Fig. 8 (Left) Flashover characteristics of solid type equipment insulator bushings

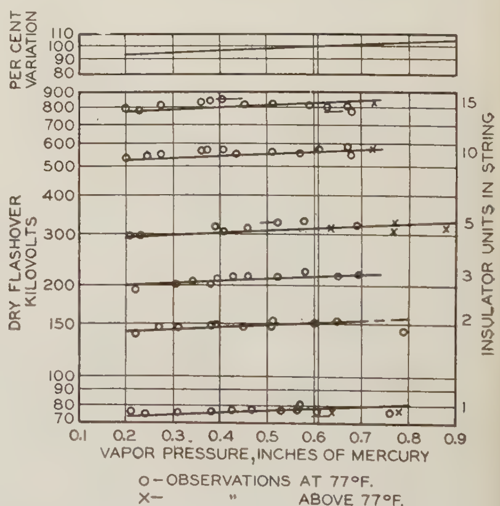


Fig. 9. (Right) Effect of humidity on the flashover voltage of standard suspension insulators

Table I—Flashover Voltages of Dirty and Salt-Coated Insulators

Condition	35-kv. Pin Type	44-kv. Pin Type	One Unit 5¾ × 10 In. Disk	Three Units 5¾ × 10 In. Disk
Dry, clean, 65% Humidity	120	135	77	204
Dry, salt-coated, 79% Humidity	97	97	34	
Dry, salt-coated, 65% Humidity	112	114	75	
Dry, dirty, 65% Humidity	116	128	69	205
Wet, clean	—	95	48	
Wet, salt-coated	34–63	52–80	27–44	
Wet, dirty	—	67–74	36–53	
In steam fog, clean	56	74.5	33	139
In steam fog, salt-coated	24	34	23	
In steam fog, dirty	48	68	32.5	114

These insulators then were flashed over, first clean and dry, then salt-coated and dry, and finally dirt-coated and dry. Tests were repeated with the insulators in a steam chamber filled with steam at a temperature of approximately 100 deg. fahr. to simulate fog conditions. Finally some of the insulators were tested as specified by the A.I.E.E. standard wet flashover test. Some typical results are shown in Table I.

It may be noted that there is but little reduction in the dry flashover voltage of the insulators when dirty. Dry tests on the salt-coated insulators were made at

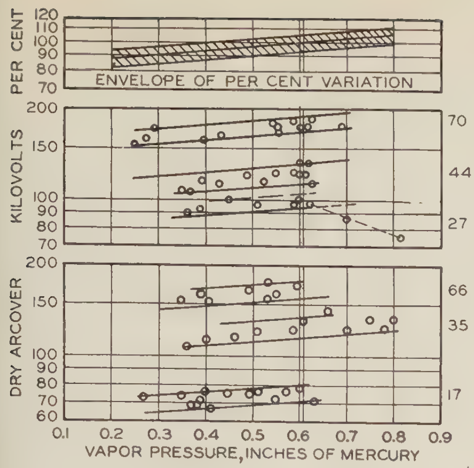
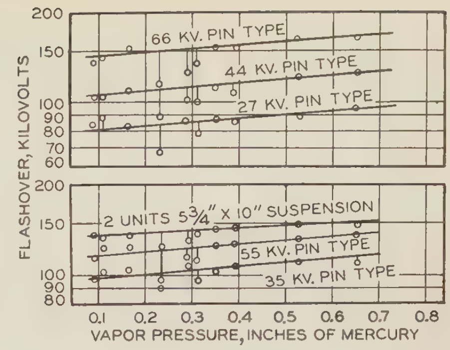


Fig. 10. (Left) Effect of humidity on the flashover voltage of pin insulators

Fig. 11. (Right) Flashover voltages of dirty insulators as a function of humidity



two humidity conditions. The first group of tests yielding the higher values in the tabulation was made at approximately 77 deg. fahr. dry bulb temperature, 65 per cent relative humidity. The second group of tests made at approximately the same temperature and at 79 per cent relative humidity gave flashover values materially lower, probably due to the absorption of moisture by the salt. At the lower humidity the dry flashover voltage of the salted insulators is nearly the same as that of clean insulators.

When subjected to artificial fog the salt-coated insulators showed in most cases a decided decline in flashover voltage; the flashover voltage of dirt-coated insulators under fog conditions also was decreased but not so severely.

In a further effort to study the effect of surface conditions on the flashover of insulators, other insulators were hung on the roof of the laboratory for a period of one year, each insulator being flashed over approximately once a month. Since the laboratory is situated in a heavy industrial district the insulators were subjected to soft coal smoke and industrial gas fumes. All flashover measurements were made at a time when the insulators apparently were thoroughly dry. These tests were made, of course, at such humidity and temperature as happened to exist at the time. Results are plotted in Fig. 11. It may be noted that the curves are identical with those of Figs. 9 and 10.

Certain points on each of the curves of Fig. 11 fall materially below the average. The low values did not occur toward the end of the exposure period as would be expected if they were due to an increase in dirt accumulation with time. In fact the reading taken at the end of the year lies on the curve very nicely at 0.659 in. of mercury vapor pressure. The group of low values recorded at 0.235 in. vapor pressure occurred after the third month of exposure. The low values shown at 0.292 and 0.314 in. vapor pressure occurred, respectively, after seven months and two months. It is believed that in these cases the dirt film on the surface was slightly moistened. Since most of the tests were made in the morning it is quite possible that in these cases there was still a small amount of invisible dew remaining on the surface of the insulators.

Agreement between the curves in Figs. 9 and 10 and those in Fig. 11 is interesting especially in view of the temperature variation in the latter tests. The highest temperature recorded during the time of exposure was 82 deg. fahr., occurring at the time of the first observation after zero time of exposure; the lowest temperature recorded was 27 deg. fahr., occurring at the test after the fourth month of exposure.

Conclusions

Relations found between arcing distance and insulator flashover and between humidity and insulator flashover are indicated in the foregoing curves and have been summarized in Table II;

Table II—General Summary of Test Data

Insulator Type	Dry Flashover Kv. per In. of Arcing Distance	Wet Flashover Kv. per In. of Arcing Distance	Wet Flashover Kv. per In. of Wet Striking Distance	Humidity Correction per 0.1 In. Mercury, Water and Vapor Pressure
Suspension (up to 100-in. string length)				
Standard cemented	10.5 to 9	7 to 6.8	———	2%
High-strength cemented	10.5 to 9	7 to 6.3	14 to 10.6	
Hewlett flat disk	10.5 to 9	7.5		
Hewlett fish tail	10.5 to 9	6.5		
Pin Types				
Small one piece	14	7.0	———	3%
Multi-part	14 to 11.4	8.9	Erratic	3%
Apparatus insulators	11 to 7.3	8 to 5.7 Erratic	13 to 10.4	2%
Equipment Bushings				
Solid type with insulated conductor	13.6 to 6.75	8.3	———	2%
Solid type with bare conductor	12.4 to 6.1	8.3		

Where two figures are given above the first applies to small insulators, and the second to the largest with fairly uniform steps between, except where noted as erratic.

the following conclusions seem justified:

1. At high relative humidities there is in some cases a scattering of test results with points falling below the humidity curves. This is believed to be due to the precipitation of a fine moisture film on the surface of the insulators.

2. Deviation of individual flashover voltages from the average are not fully explained by humidity variations alone. After correction for humidity has been made, a variation of about plus or minus 5 per cent remains in some cases.

3. The same humidity corrections are applicable to dry, dirty insulators as to clean insulators.

4. Dry dirt on the insulator surfaces only slightly lowers the flashover voltage, but a small amount of moisture greatly reduces the flashover voltages of dirty insulators, particularly if the dirt is of a saline nature.

5. At high relative humidities the flashover voltages of salt-coated insulators is materially reduced due to absorption of water by the salt.

II—Factors Affecting Insulator Sparkover

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WHILE the mechanical properties and strength of the various parts entering into the design of a modern transmission system are quite well known, the electrical characteristics of the various parts often are not so definitely understood. This is true particularly of the electrical properties of the insulating parts, including the line and station insulation and bushings used in the station equipment. In this article are presented data on the sparkover strength of the various parts used for the insulation of modern high voltage transmission systems. Results are given of tests made to determine how insulator sparkover is affected by various factors.

The more common factors having a direct influence on the sparkover voltage of insulators are: temperature, barometric pressure, humidity, smoke, steam, dew, fog, rain, and surface dirt and moisture. Effects of temperature and barometric pressure on the 60-cycle sparkover voltage were determined some years ago. On the basis of these earlier studies it is generally sufficiently accurate to assume that the change in sparkover voltage is directly proportional to the change in air density; this holds true for both 60-cycle and lightning or impulse voltages. All sparkover voltages in these tests have been corrected to an air density of unity, using correction factors determined in the earlier tests.[1,2]

Regarding the effects of humidity but little data heretofore have been published.[3,4] Tests made in different laboratories, under identical conditions in so far as A.I.E.E. specifications are concerned, often fail to produce identical results. For the most part these differences can be attributed to the effect of humidity or water vapor in the atmosphere in which the tests are made. Effects of some of the remaining factors enumerated in the preceding paragraph have been recognized for some time but in most cases specific quantitative data have been lacking. Accordingly, some heretofore unpublished data on the effects of these factors are presented in this article.

Humidity

When the humidity for a given sparkover test has been specified, common practise has been to express it in terms of relative humidity. No confusion would result by such a procedure if all sparkover tests were made at approximately the same temperature. The effect of humidity then would be indicated by plotting sparkover voltage as a function of relative humidity. Sparkover tests, however, sometimes are made over a wide range of temperature, but the results so plotted are of little value in comparing the humidity effect and in finding an agreement in the sparkover voltage at some given humidity. A single curve of sparkover voltage as a function of relative humidity for different temperature cannot be drawn; the effect can be shown only by drawing a group or family of curves, each individual curve pertaining to one particular temperature.

Since humidity generally has been expressed in relative values, it has been difficult to interpret its true effect; hence different laboratories have found it hard to agree upon the sparkover voltage at any given humidity. When reduced to an absolute-humidity basis, however, the tests made by different laboratories show strikingly similar results; this is revealed by the curves shown in Fig. 12. These tests have been made with four different sets of testing equipment in four laboratories. Three of the laboratories employed artificial humidity control; the fourth was an outdoor laboratory in Pittsfield, Mass., under natural humidity conditions occurring from day to day and season to season. All these tests were conducted in accordance with A.I.E.E. Standard No. 41. The dip in these curves beyond a density of about 9 grains per cu. ft. will be discussed later.

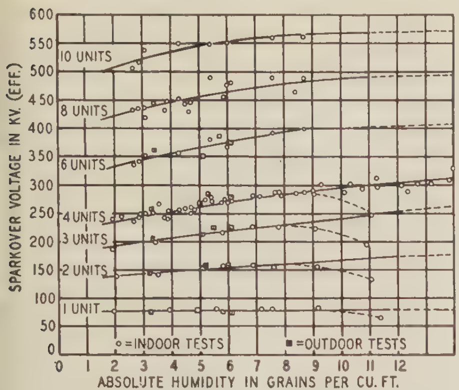
Effects of humidity on the sparkover voltage of standard-duty suspension insulators of different sizes and having different spacings are shown in Figs. 12, 13, and 14; Fig. 15 shows the effect of humidity on certain sizes of pedestal insulators and a large pin insulator.

The sphere-gap appears to be practically independent of humidity effects. This is not true of the needle-gap, however, as may be seen from Fig. 16. These data are in agreement with previous data on the effect of humidity on the sparkover of spheres and needles.[4,5] In Fig. 17 the data of Fig. 16 are rearranged to show sparkover voltage as a function of gap spacing; the standard needle-gap curve also is indicated.

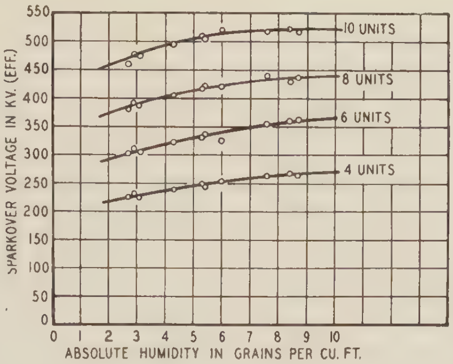
It may be noted that several of the humidity-sparkover curves for insulators indicate a lowering of

Based upon "Insulator Sparkover—Factors Affecting the Sparkover Voltage of Insulators Used on High Voltage Transmission Systems" (No. 32-59) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

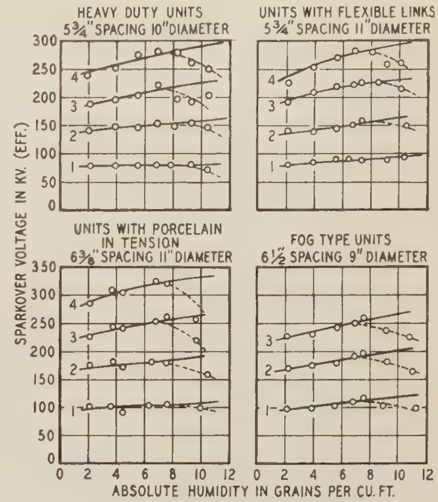
the voltage sparkover for absolute humidities above approximately 9 or 10 grains per cu. ft. That this is an effect of surface moisture or condensation on the porcelain surfaces of water vapor from the atmosphere at these high absolute (and generally relative) humidities, and not an effect in the air-gap, is indicated by the absence of this effect in the curves for the needle-gap and sphere-gap, particularly the



10-in. standard-duty units, $5^3/_4$-in. spacing



10-in. standard-duty units, $4^3/_4$-in. spacing



(Right) Units of different sizes with different spacings

Figs. 12, 13, and 14. Effect of humidity on the 60-cycle sparkover of suspension insulators

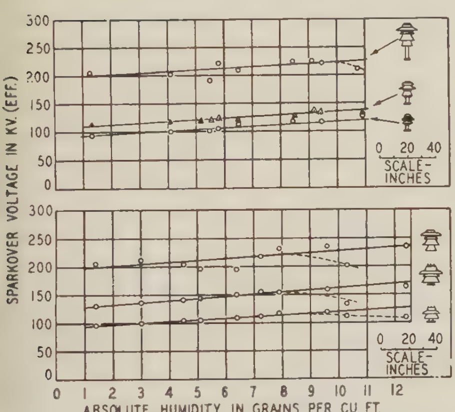
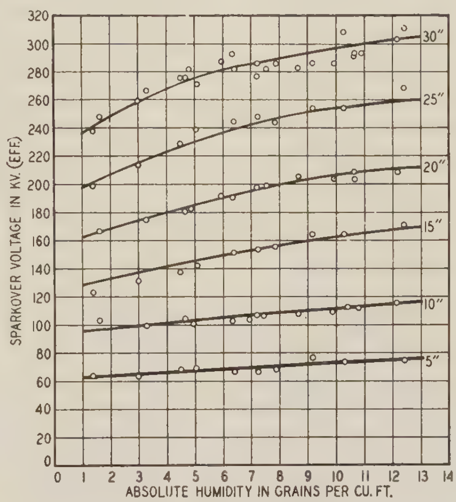
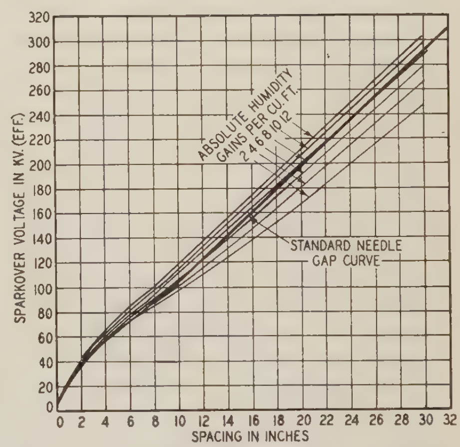


Fig. 15. Effect of humidity on the 60-cycle sparkover of pin and pedestal insulators





Figs. 16 (left) and 17 (above). Effect of humidity on the 60-cycle sparkover of the needle-gap

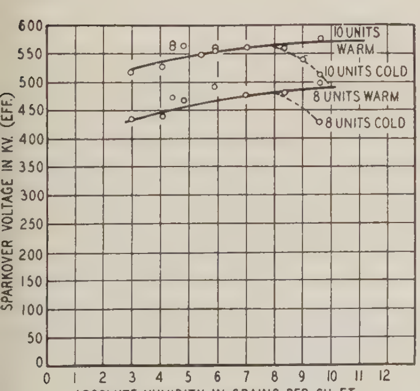


Fig. 18. Effect of humidity on the 60-cycle sparkover of suspension insulators showing influence of condensed moisture on surface of insulators at high humidity

10-in. standard-duty units, $5^3/_4$-in. spacing

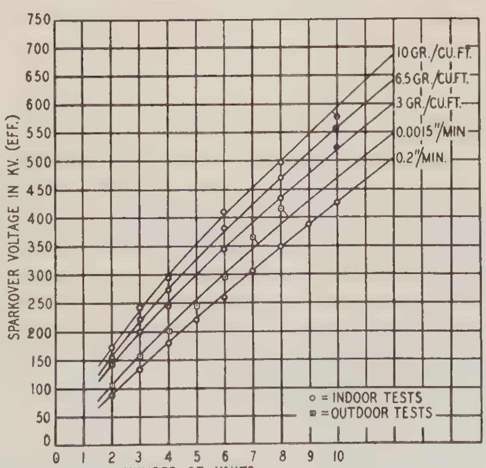


Fig. 19. Effect of rain on the 60-cycle sparkover of suspension insulators

10-in. standard-duty units, $5^3/_4$-in. spacing

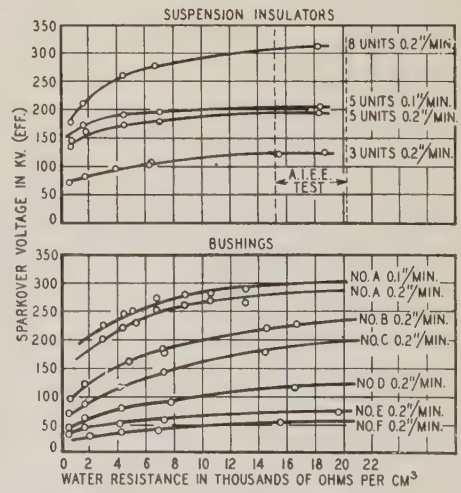


Fig. 20. Effect of water resistance on the wet sparkover of suspension insulators and bushings at 60 cycles

former. This conclusion is indicated also by the data in Fig. 18 where tests were made on chilled and slightly heated insulators. It is indicated also by the difficulty commonly experienced when tests on insulators at high humidities show a constantly rising sparkover voltage in repeated tests. The surface moisture results in low sparkover voltage in the initial test; repeated sparkovers remove this surface moisture and the insulator gradually acquires the higher sparkover voltage resulting from the high humidity. Frequently this increase continues for 25 or more tests before the sparkover voltage becomes constant at the upper value.

Smoke, Atmospheric Moisture, and Surface Dirt and Moisture

In this portion of the investigation 60-cycle sparkover tests were made on 10-in. standard duty suspension insulators with $5^3/_4$-in. spacing in atmospheres of smoke, steam, dew, fog, rain, and on insulators coated with surface dirt and moisture. Results of these tests are shown in Figs. 19, 20, and 21.

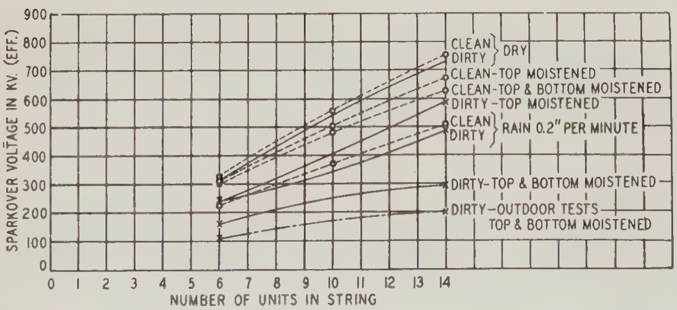
Results of tests made under dry, light rain, and heavy rain conditions are shown in Fig. 19; these are for insulators in a vertical position. Rain tests with the insulators in a horizontal position indicate no lowering of the sparkover potentials with the rain directed either at right angles to the string, or either from or toward the line end at an angle of 45 deg. to the string, and at 45 deg. from the vertical in all cases. On a horizontal string, rain improves the voltage distribution along the string sufficiently to raise the rain sparkover potentials to that of the dry. In the vertical position the drip along the vertical axis overbalances this effect and actually lowers the sparkover potentials. In Fig. 20 are shown the variations of sparkover voltage with resistivity of the water and rate of precipitation for clean insulators and bushings.

The effects of dirt and moisture on the 60-cycle sparkover are shown in Fig. 21. For these tests the insulators were exposed for a long time to the steam and smoke from a locomotive until they were coated with a carbon deposit perhaps $^1/_{32}$ to $^1/_{16}$ in. in thickness. From Fig. 21 the following observations may be made.

1. When dry the deposited dirt had practically no effect upon the insulator sparkover.

2. Sparkover potentials for the dirty insulators with top surface moistened were but slightly lower than for clean insulators with top and bottom surfaces moistened.

3. Clean and dirty insulators had approximately the same sparkover potentials under artificial rain conditions of 0.2 in. per min. at 45 deg. from vertical, as specified by A.I.E.E. tests. This was presumably because some washing of the insulators took place.



4. Dirty insulators with both top and bottom surfaces moistened (by light spraying) had low sparkover voltages.

5. Under conditions just indicated in item 4, combined with an atmosphere of heavy steam and locomotive smoke surrounding the string, the sparkover voltages were the lowest of any measured in these tests.

Lightning Sparkover

Results of tests to determine the effect of humidity upon lightning sparkover of different insulators are given in Fig. 22. It may be noted that the variation in sparkover potential between a density of 3 and 10 grains per cu. ft. was found to be approximately plus and minus 10 per cent for the sizes tested. This is of the same order as with 60-cycle voltages. Similar tests made on various gaps show corresponding results. Dew, fog, rain, and surface moisture were found to have but little effect upon the lightning sparkover of insulators, but in general their effect decreases as the length of the wave decreases.

Tests on wood poles and crossarms, with and without porcelain insulators mounted on the arms, exhibit lightning sparkover characteristics similar to those of porcelain insulators alone. Wood poles, crossarms, and guy insulator sticks of different cross-sectional areas have a lightning sparkover potential of approximately 175 kv. per ft. of length, whether the wood be dry or wet with clean water or saturated with salt water and brine.[6] The probable reason for this is that water is a fairly good insulator for impulse voltages as compared with air in which these materials ordinarily are tested.

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Fig. 21. (Left) Effect of surface moisture and dirt on the 60-cycle sparkover voltage of suspension insulators; 10-in. units with $5^3/_4$-in. spacing

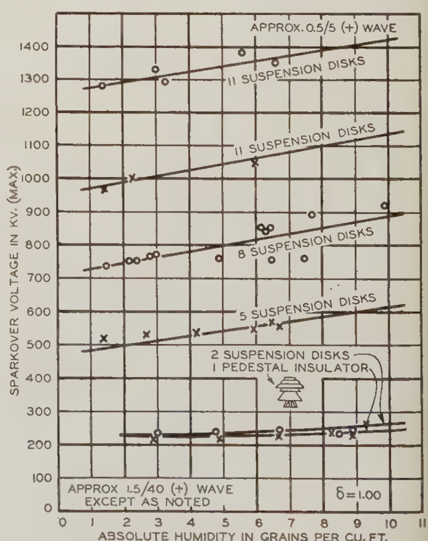

Fig. 22. (Right) Effect of humidity on the lightning sparkover of insulators

III—Designs and Economics of Suspension Insulator Strings

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IN THE PAST the effectiveness of transmission line insulation has been judged almost entirely by its 60-cycle flashover characteristics. On this basis the wide changes in spacing and diameter of suspension insulator units have affected the overall flashover values but little. Recently, however, it has been realized that the criterion for insulation should be based upon impulse flashover characteristics rather than upon the 60-cycle behavior. Limited laboratory tests using impulse voltages showed that the impulse flashover voltage of insulator strings is changed appreciably by varying the diameter and spacing of the individual units. Economic studies show that, in general, low cost is associated with large diameter units spaced close together.

In a paper presented by Messrs. Fortescue and Conwell, and a discussion of that paper ("Lightning Discharges and Line Protective Measures," by C. L. Fortescue and R. N. Conwell, A.I.E.E. TRANS., v. 50, 1931, p. 1090–1100; discussion p. 1147) it was shown that on a transmission line equipped with ground wires, the reflections from tower footings altered the wave form so that the resultant voltage across the insulators had the approximate shape of the wave shown in Fig. 23. If the insulators are to be subjected chiefly to this type of wave, it is essential to determine how the insulators will perform under such waves.

To be comprehensive, an investigation of the characteristics of insulators should be made on a volt-time basis; that is, waves of long duration should be applied to the insulators, and the voltage varied so that flashover will take place in time lags ranging from sixteen or more microseconds down to one or two. The performance of the insulation then should be judged according to its application: If it is to be used on lines equipped with ground wires, the performance of the insulation should be judged by the flashover voltage at short periods of time; if it is to be used on lines not equipped with ground wires, its performance should be judged by long time lags as well as short. However, the majority of the transmission lines now being planned and constructed are to be equipped with ground wires. Therefore, the emphasis of this analysis will be placed on short time flashovers.

Based upon "Suspension Insulator Assemblies, Their Design and Economic Selection" (No. 32–61) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

Tests Establishing a Comparison Basis

Laboratory tests were made on suspension insulator assemblies and on bushings with the voltage wave shown by the oscillogram of Fig. 24. This voltage wave closely resembles the calculated curve shown in Fig. 23. The principal object of these tests was to determine the relation between flashovers with this type of wave and those given by standard volt-time curves.

The following crest voltages are the minimum values causing flashover of insulator assemblies made up of 10-in. units spaced $5^3/_4$ in. apart, when subjected to this type voltage wave:

No. Units	Crest Voltage (kv.)
8	1,050
10	1,240
12	1,550
14	1,800

From the volt-time curves shown in Fig. 25 it can be seen that these voltages correspond to flashovers at some time lag between 1 and 2 microsec. on $1^1/_2$–40 positive-wave volt-time curves. (A $1^1/_2$–40 wave is one in which the time from zero to crest is $1^1/_2$ microsec. and the time from to crest to half voltage on the tail of the wave is 40 microsec.) The minimum flashover voltage decreases and corresponds to longer time lags when longer-duration test waves are used. It has been shown previously that longer waves than that shown in Fig. 23 may be expected on lines having high tower footing resistances, and that effective ground wire protection can be had only with tower footing resistances less than 10 ohms. With higher tower footing resistances voltages appearing across the insulators become so high that it is uneconomical to insulate against strokes of even moderate intensity. For these reasons, the comparison of insulators for use on lines properly equipped with ground wires should be made at 2 microsec. as taken from volt-time curves.

Special field conditions may require a different wave upon which to base analyses; consequently, provisions were made for varying the magnitude of the $1^1/_2$–40 microsec. positive wave used in these tests, so as to give time lags of flashover ranging from 1 to 20 microsec. The results then were plotted in the form of volt-time curves from which insulator performance can be ascertained for any predetermined wave shape. In the event that some peculiar local condition necessitates the choice of an irregular wave as a basis of test, it is necessary to test only one combination of insulators with this wave. The flashover voltage values then may be referred to the volt-time curve to ascertain the corresponding time lag. The comparison of various types of insulators can be made at the corresponding time lag from their respective volt-time curves.

If the high voltage transmission line is not protected by ground wires, or if the ground wire protection is inadequate, then the voltage wave form across the insulators is not accompanied by reflections from tower footings; therefore the wave shape approximates that of the lightning discharge. The

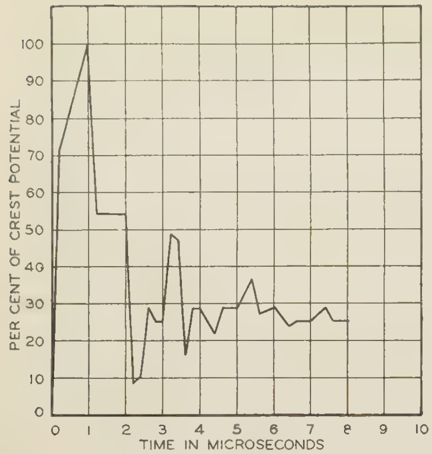

Fig. 23. Calculated wave shape of voltage impulse on a transmission line equipped with ground wires

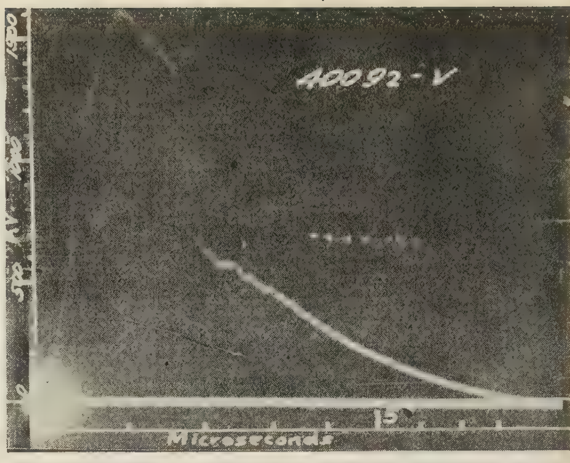

Fig. 24. Oscillogram of voltage impulse used for the tests described in this article

wave form in this case is of longer duration, ranging from 10 to 50 microsec.

Diameter and Spacing Tests

To determine the relation between insulator dimensions and flashover characteristics of suspension insulator assemblies, a series of tests was conducted for which insulators of the cemented cap and pin type were made in a variety of shell diameters and unit spacings. The porcelain shells were standard in head, petticoat, and shed droop design except for a special $10^1/_2$-in. diameter unit designed for coastal duty. This unit had 10 per cent greater shed droop than the standard design. Heads of all these units were the same size so that all hardware was identical; this head size was the same as that of a standard-strength unit now most commonly employed upon high voltage lines.

Shell diameters of the insulators tested were, respectively, 7, $8^1/_2$, 10, $10^1/_2$, 12, and 14 in. Unit spacings ranged from a minimum possible value to a maximum value considerably greater than any spacing that has been employed for line insulation. The specific spacings used in the tests were, respectively, $4^3/_4$, $5^3/_4$, $6^1/_2$, $7^1/_2$, and 10 in. These variations in spacing were obtained by pins of various lengths being screwed into a threaded socket provided on the stud. This arrangement materially reduced the number of units required for the tests and afforded more comparable data because identical shells of each diameter were tested at all spacings.

Conventional 60-cycle dry and wet flashover tests were performed on strings of 4, 8, 12, and 16 units of each dimension combination; that is, the units in each string assembly were all of the same diameter and spacing. No non-uniform string assemblies were tested because these conglomerations have been found to be impractical line assemblies. The tests were made in accordance with A.I.E.E. Standard No. 41 pertaining to the conduct of normal frequency flashover tests.

Impulse flashover tests were made on the same string assemblies with a $1^1/_2$–40 microsec. wave of positive polarity. A cathode ray oscillogram was made of each impulse flashover, over 700 such records being obtained. These data were corrected for variations in atmospheric temperature and density, but no correction was made for the recorded relative humidity which ranged between 10 and 15 per cent. Correction factors for humidity have not been established, but at present are under consideration by the A.I.E.E. lightning and insulator subcommittee. It is the authors' opinion that the variation in impulse flashover voltage caused by changes in humidity during these tests is negligible. This opinion is based upon wet and dry impulse flashover tests.

Some of the data obtained from the impulse tests on various insulators are given in the replotted curves shown in Fig. 25. These curves were obtained from time lag curves, each of which was plotted from an average of 13 points. Some combinations of unit dimensions were not tested under the impulse wave as the test would become too long. The omitted combinations were so selected that they could be readily interpolated from the other tests.

Units found to be most effective under impulse tests were subjected later to arc tests to check the behavior of these diameter shells under high current impulses and power follow arcs. An eight-unit string of 12-in. diameter shells was subjected to more than 100 severe impulse flashovers, in addition to the normal impulse flashover characteristic tests, at an approximate rate of voltage rise of 6,000 kv. per microsec., and a current of approximately 5,000 amperes. These same units then were subjected to 60-cycle arcs of approximately 3,000 amperes for a duration of 2 sec. Since the 10-in. unit is the most common in practical use, this was chosen as a reference for comparison with the 12-in. unit. In the impulse tests neither the 10-in. nor the 12-in. units failed either by puncture or breakage. In the 60-cycle arc tests the performance of the 12-in. unit was as good if not slightly better than the 10-in. unit. These results are substantiated by service data available. All tests reported in this paper were made without auxiliary electrodes, such as rings and horns. The effect of such devices already has been investigated ("Impulse Flashover of Insulators," by J. J. Torok and R. Ramberg, A.I.E.E. Trans., v. 48, 1929, p. 239–45).

Cost Considerations

In the selection of high voltage transmission insu-

ators, the designer is confronted by two major considerations: first, the permissible cost of line insuation; and second, the selection of the maximum nsulation available for that cost. Once the permissible cost of insulation has been decided upon, he most economic suspension insulator unit can be selected from examination of insulation and cost characteristics similar to those shown in Figs. 26 and 27. In Fig. 26 is shown the impulse flashover characteristics with respect to string length, of various assemblies of 10-in. and 12-in. diameter shells. These flashover voltages were taken at a 2-microsec. time lag for reasons advanced previously. It may be noted that for a given unit spacing and flashover voltage strings comprised of 12-in. shells are appreciably shorter.

In both Figs. 26 and 27, string length was chosen as the basis of reference, as it is a controlling factor in supporting structure dimensions. For a given flashover voltage, the shorter string length is more desirable on a tower cost basis, as it may reduce the length of the arm and height of the tower; or, with a given string length and the utilization of a more effective insulator, the flashover voltage will be increased and the number of outages due to lightning will be decreased. For example, in Fig. 26, a 1,500-kv. flashover at a 2-microsec. time lag is provided by a string length approximately 65 in. when composed of 12-in. units spaced $4^3/_4$ in., and by a string length approximately 91 in. when composed of 10-in. units spaced $6^1/_2$ in. A difference of 26 in. exists between the lengths of these strings. A steel tower design for use with the longer string of course would be appreciably heavier and more expensive than a tower with the same clearances and line height designed for the shorter string. Using 12-in. units spaced $4^3/_4$ in., a string length of 91 in. would have a flashover of 2,050 kv. as against 1,500 kv. for a string of the same length using 10-in. units spaced $6^1/_2$ in. apart. This means that an increase in flashover potential of 550 kv. is obtained by using the more efficient combination of diameter and spacing. These factors should exert considerable influence upon the choice of properly dimensioned suspension units.

Economic Selection

To provide economic comparison curves the 2 microsec. time lag flashover characteristics of Fig. 26 were incorporated with the cost of the units to give the curves shown in Fig. 27. Cost values employed were those for a purchaser with packing and shipping expenses allowed to a shipping point 500 miles from the factory, and are based upon the physical dimensions of the units. Up to approximately 70-in. string length, a 12-in. unit spaced $6^1/_2$ in. provides insulation at the least insulator cost. This point corresponds roughly to the insulation considered as economically balanced for 138-kv. transmission on steel towers adequately protected by ground wires.

Beyond a string length of 70 in., a 12-in. unit

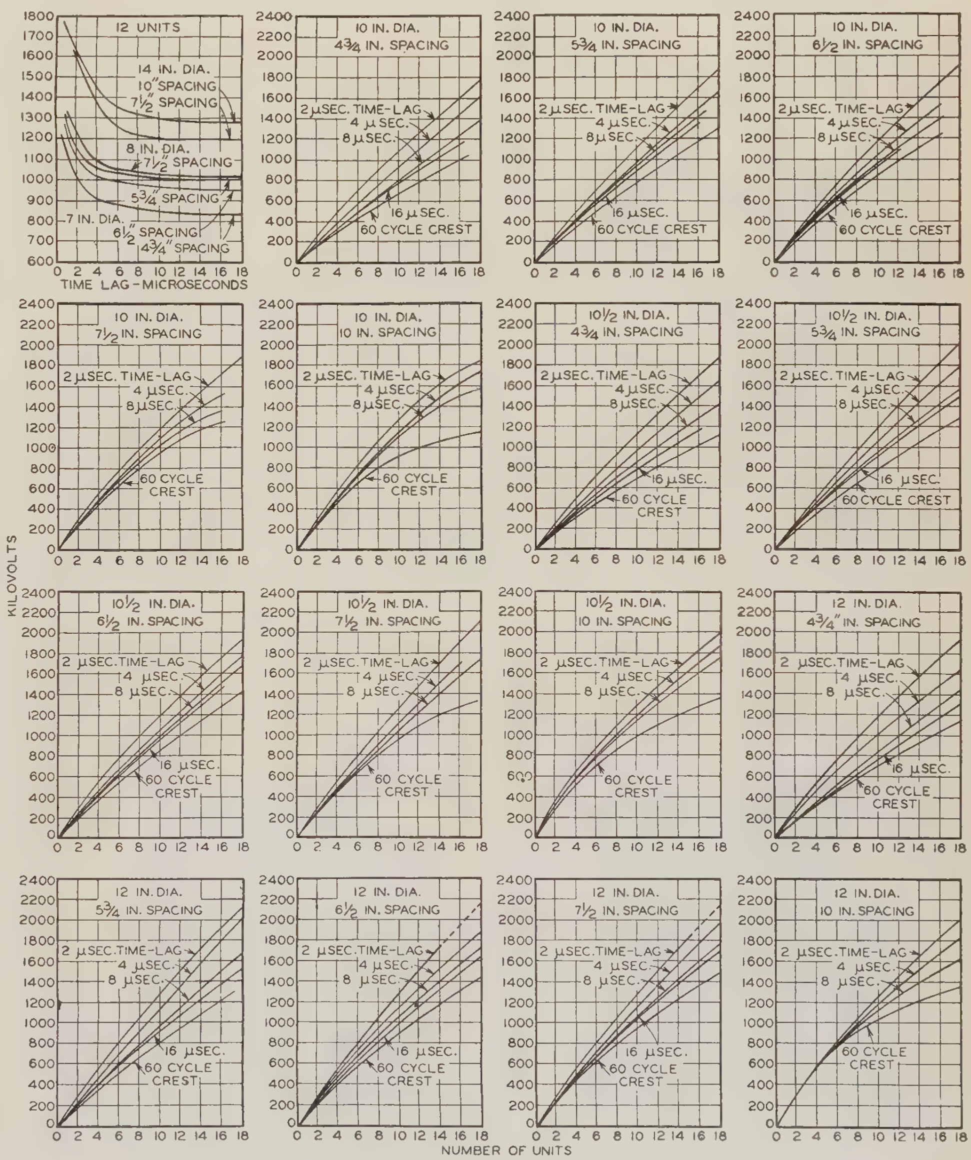

Fig. 25. Flashover characteristics of suspension insulators

All vertical scales show minimum flashover potential in kv.; horizontal scales (except upper left) show number of insulator units in the string

spaced $5^3/_4$ in. shows the lowest insulation cost. Units 10 in. in diameter spaced $4^3/_4$ or $5^3/_4$ in. are the dimension combinations most commonly used at the present time for those string lengths. However, these units show much higher relative costs than 12-in. diameter units at the same spacing for string lengths of more than 30 in. Incidentally, a string length of 30 in. corresponds roughly to economically balanced insulation commonly employed for 69 kv.

Further examination of these flashover and cost curves clearly indicates a wide range of selection in the choice of the proper insulation. It should be noted, however, that to determine the maximum insulation for the least cost, Figs. 26 and 27 must be employed simultaneously. For example, at approximately 65-in. string length, 12-in. units spaced $5^3/_4$ in. provide a 1,500 kv. flashover rating at a relative cost of 1.76 or an arbitrary total cost of 2,640; whereas 10-in. units spaced $6^1/_2$ in. must have a string length of approximately 91 in. to provide the same flashover rating. This gives an arbitrary total cost of 1.93 times 1,500 which is 2,900 or approximately 10 per cent higher in cost with a 32 per cent increase in string length.

Low-cost units have been proposed for light duty, such as on wood construction and lower voltage transmission lines. Economic characteristics of such a unit are shown by the 9-in. diameter, 5-in. spacing curve of Fig. 27. Obviously, for light duty service requiring insulation corresponding to 60-in. string length (approximately 138 kv.) such units are desirable economically. For example, assume a 40-in. string of 9-in. units spaced 5 in. apart; from Fig. 26 this combination gives a flashover potential of 875 kv. at 2 microsec. time lag at the relative cost (Fig. 12) of 1.35 per kv. An equivalent string of 12-in. units, spaced $5^3/_4$ in. must have a length of approximately 40 in.; its relative cost is 1.7. Thus for the same electrical characteristics, the small unit shows a 20 per cent saving in cost. The economy of this smaller unit is the result of reduction in head size and consequently lower mechanical strength.

In wood pole construction, present practise is to use just sufficient porcelain to insulate the line for the normal operating voltage, and to depend upon the wood for impulse insulation. The insulator to be used for this type of service should have a low cost per kv. of 60-cycle flashover potential and mechanical strength slightly above that of the wood structure. Calculations of ultimate strengths of wooden structures now in use show that a unit having a mechanical strength of 7,000 lb. would be adequate.

Conclusions

Principal findings of this study may be summarized as follows:

1. Two major factors in the design of steel tower transmission lines are (1) the shielding of the power conductors with properly located ground wires, and (2) maintaining the tower footing resistances as low as possible.

2. For towers of low footing resistance (on the order of 20 ohms) the wave is of short duration so that the minimum flashover voltage of the attached insulation corresponds to its breakdown voltage at 2 microsec. with a flat-topped wave.

3. In applying insulation to well protected high voltage lines, suspension insulators should be judged on the basis of their impulse flashover characteristics at 2 microsec.

4. Choice of insulation for lines either not protected or inadequately protected by ground wires is based upon impulse flashover values at long time lags, of the order of from 10 to 50 microsec.

5. Impulse flashover space effectiveness of suspension insulators improves with an increase in unit shell diameter at moderate spacings.

6. Impulse flashover space effectiveness for all unit diameters falls off with increase in unit spacing.

7. Flashover space effectiveness decreases with increase in string length.

8. Insulation cost for a given impulse flashover voltage generally is lower for larger diameter units and higher for larger unit spacings.

9. Available service data and laboratory tests show that a 12-in. unit is as serviceable as a 10-in. unit.

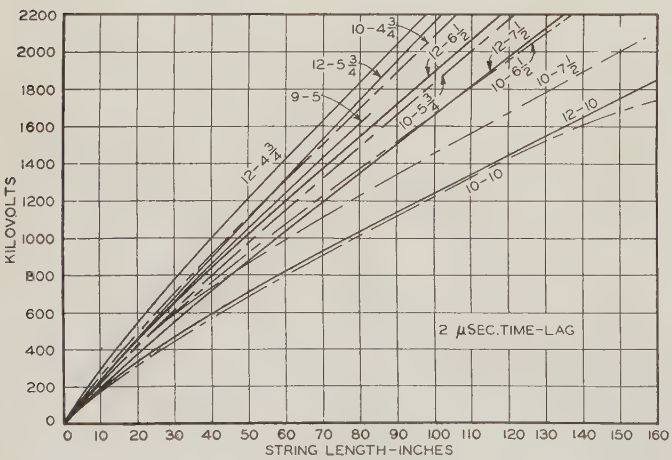

Fig. 26. Suspension insulator flashover characteristics as a function of string length

Numerals associated with the various curves indicate, respectively, the diameter of the individual units and the spacing between, both in inches

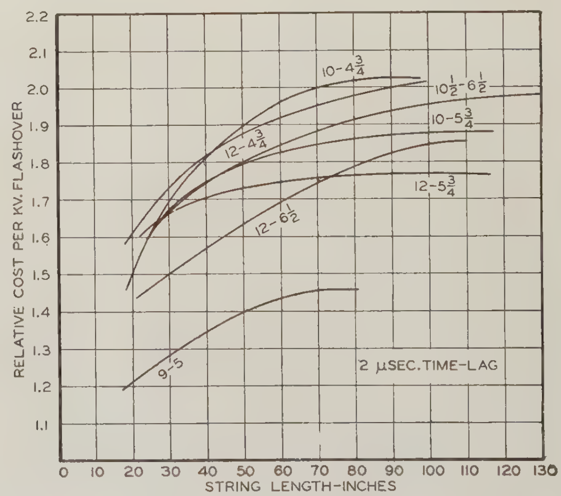

Fig. 27. Relative costs of suspension insulator strings

Numerals associated with the various curves indicate, respectively, the diameter of the individual units and the spacing between, both in inches

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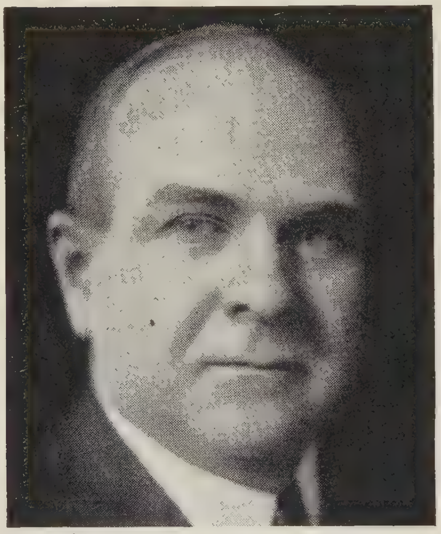

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Pacific Coast Convention Program Announced

TECHNICAL and entertainment programs have been arranged for the Institute's Pacific Coast convention to be held at Vancouver, B. C., August 30 to September 2, 1932 and promise 4 days which should be truly inspirational to members and guests. In addition to the formal program there are excellent facilities for all types of sports and entertainment for those intending to spend their vacation in Vancouver.

Technical Sessions

Fourteen papers offer a variety of subject matter embracing both theory and recent practise in the electrical engineering field. These will be presented in 4 sessions, one each on the following: power generation; transportation, electrical machinery and metering; transmission and communication; and station apparatus. Those interested in power system developments and the segregation of hydroelectric power costs should find the first session of particular interest to them. The second and fourth sessions should appeal to those who are theoretically inclined, as they contain valuable papers in the measurements field, such as metering of symmetrical components and high accuracy bushing current transformers. Other subjects—circuit breakers, factory assemblies for substations, and the theory of the 3-wire d-c. generator with 2-wire static balancer—lend variety to these sessions. The third session should prove to be of general interest as it contains several papers in the power transmission field which are theoretical and several others describing large radio systems, a subject of broad appeal. In addition, at one of these sessions there will be presented 2 papers on railway electrification which are of popular interest.

Entertainment Features

On the evening of the opening day, Tuesday, August 30, the president's reception will be held in the Hotel Vancouver. Following the reception, there will be a dance in the Oval Room, dress being optional.

The boat trip on the second day, August 31, will consist of a 4-hr. cruise on the S. S. "Princess Norah" around Vancouver harbor and the surrounding coast. The harbor is some 2 miles long and is set amid truly wonderful mountain scenery. Dinner will be provided on the boat, also an orchestra, and arrangements are being made for dancing on the deck.

A golf tournament will be held on September 1 at the Shaugnessy Heights Golf Club. That evening a banquet will be held in the Oval Room of the Hotel Vancouver, followed by the presentation of golf prizes and a good program of entertainment.

At the luncheon to be held under the auspices of the Electric Club on September 2, the speaker will be Capt. E. A. Wheatley, registrar of the Association of Professional Engineers in British Columbia, and his subject will be "Engineering Legislation." Captain Wheatley is a pioneer in the movement to raise the status of the professional engineer to that of the doctor or lawyer. He is intensely enthusiastic and is remarkably well informed. It is felt that his address will be of vital interest to all.

On the afternoon of September 2, inspection trips will be made by groups in private cars, including a visit to the University of British Columbia, as well as to a number of other points of interest. During the same afternoon, a bridge tea will be held for the benefit of the women. For those attending the student conference, a dinner will be held that evening at Union College, University of British Columbia. This will be followed by a student conference.

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Aerial view of the business section of Vancouver, B. C., scene of this year's Pacific Coast convention of the Institute, August 30–September 2, 1932

Registration

A fee for "banquet and entertainment tickets" will be payable at the time of registration. These tickets will cover the dance after the president's reception on August 30, the boat trip on August 31, and the dinner on the boat, the banquet on September 1, and in the case of the women, the bridge tea on September 2. The charges for these tickets will be as follows:

Members and men guests	$7.50 per strip
Ladies	6.00 per strip
Students	2.50 per strip

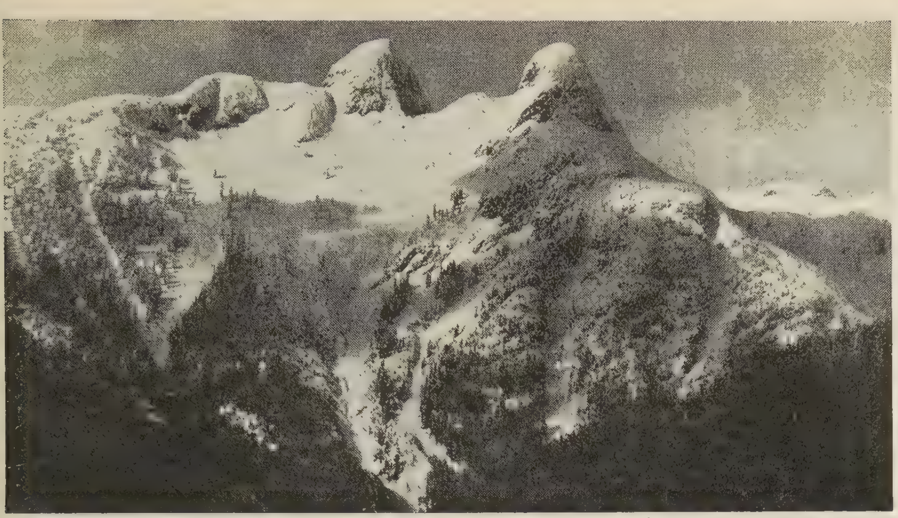
Tickets for individual functions will be sold only to students.

Rates which will prevail at the Hotel Vancouver, convention headquarters, are as follows:

Double room, with bath	$6.00
Single room, with bath	4.00
Double room, without bath	5.00
Single room, without bath	3.00

The Terminal City Club, 837 West Hastings Street, Vancouver, will accommodate visiting students at $1 per day.

Regarding transportation, the annual summer excursion rates will be in force and therefore no steps have been taken to obtain special rates. Vancouver may be reached from practically any part of the Pacific states by road, rail, air, or water.



© Canada, Leonard Frank

"The Lions," famous mountain peaks near Vancouver, B. C.

COMMITTEES

General convention committees and officers serving in the various departmental divisions of convention activities are:

Chairman, G. R. Wright (A'12) district manager, Canadian General Electric Company, Ltd., 1065 Pender Street, West, Vancouver, B. C.; *vice-chairman*, L. B. Chubbuck (M'26) switching equipment engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada; *secretary*, W. D. Robertson (A'27) central station engineer, Canadian General Electric Company, Ltd., Vancouver, B. C.; *treasurer*, C. Arnott (A'27) electrical draftsman, British Columbia Electric Railway Company, Ltd., 425 Carrall Street, Vancouver, B. C. Committee chairmen include: F. W. MacNeill (M'22) *entertainment;* J. R. Read ('04) *finance;* A. Vilstrup (M'27) *hotels and registration;* V. W. M. Fouracre (A'31) *publicity;* L. B. Stacey (M'29) *reception;* J. Teasdale (A'24) *technical program;* E. G. Cullwick (A'26) *student activities;* C. W. Colvin (M'21) *transportation;* D. de M. Mertens (M'25) *golf;* and Mrs. F. W. MacNeill, *ladies' entertainment*. These are assisted by P. S. Biegler (F'29), E. A. Crellin (F'28), M. T. Crawford (F'22), R. J. Davidson (A'21), J. H. Hamilton (A'28), Paul Ransom (M'31), L. E. Reukema (A'24), J. A. Thaler (F'13), H. Vickers (M'26), and H. L. Vincent (A'25), all members of the local committee.

Program

All technical sessions and the opening of the convention will be held at the Hotel Vancouver. Abstracts of papers to be presented at the sessions are scheduled for publication in the August 1932 issue of ELECTRICAL ENGINEERING.

Tuesday, August 30

9:30 a.m.—Registration

9:15 a.m.—Meeting of District Student Committees

10:00 a.m.—Opening of Convention by President H. P. Charlesworth

10:30 a.m.—Power Generation

*THE POWER SYSTEM OF THE BRITISH COLUMBIA POWER CORPORATION, LTD., E. E. Carpenter, British Columbia Electric Railway Co.

*ROCK ISLAND DEVELOPMENT OF THE PUGET SOUND POWER & LIGHT CO., A. P. Newberry, Puget Sound Power & Light Co.

*SEGREGATION OF HYDROELECTRIC POWER COSTS, W. S. McCrea, Jr., Dept. of Public Works, State of Washington.

12:00 m.—Luncheon, Students and Counselors

2:00 p.m.—Transportation, Electrical Machinery, and Metering

READING COMPANY'S PHILADELPHIA SUBURBAN ELECTRIFICATION, G. I. Wright, Reading Co.

*ELECTRICAL OPERATION ON THE CASCADE DIVISION OF THE GREAT NORTHERN RAILWAY, J. B. Cox, General Electric Co.

THEORY OF THREE-WIRE D-C. GENERATOR WITH TWO-PHASE STATIC BALANCER, E. G. Cullwick, University of British Columbia.

*METERING OF SYMMETRICAL COMPONENTS, G. R. Shuck, University of Washington

8:00 p.m.—President's Reception

Wednesday, August 31

8:00 a.m.—First Student Session

12:00 m.—Luncheon, Institute District and Section Executives and Student Counselors

2:00 p.m.—Second Student Session

5:30 p.m.—Boat Trip

Thursday, September 1

9:00 a.m.—Station Apparatus

*SHAPING OF MAGNETIZATION CURVES AND THEORY OF THE ZERO ERROR CURRENT TRANSFORMER, A. C. Schwager and V. A. Treat, Pacific Electric Mfg. Corp.

*FACTORY ASSEMBLIES FOR SUBSTATION DESIGN, H. M. Hobbs, Westinghouse Elec. & Mfg. Co.

*OPERATING EXPERIENCE WITH HIGH VOLTAGE CIRCUIT BREAKERS, R. E. Rowley, Dept. of Water & Power, City of Los Angeles

2:00 p.m.—Golf Tournament

7:30 p.m.—Banquet

Friday, September 2

9:00 a.m.—Power Transmission and Communication

*CORONA LOSS MEASUREMENTS FOR THE DESIGN OF TRANSMISSION LINES TO OPERATE AT VOLTAGES BETWEEN 220 KV. AND 330 KV., J. S. Carroll, Stanford University, and B. Cozzens, Dept. of Water & Power, City of Los Angeles

*THE TRIPLE HARMONIC CIRCUIT IN THREE-PHASE POWER SYSTEMS, T. H. Morgan, Worcester Polytechnic Institute, and C. A. Bairos and G. S. Kimball, Stanford University, Calif.

*THE RADIO PLANT OF THE R. C. A. COMMUNICATIONS, INC., H. H. Beverage, C. W. Hansell, and H. O. Peterson, of R. C. A. Communications, Inc.

*RADIO LINKS IN THE SYSTEM OF THE BRITISH COLUMBIA TELEPHONE CO., C. H. McLean, British Columbia Telephone Co.

12:15 p.m.—Electric Club Luncheon

2:00 p.m.—Inspection trips

2:00 p.m.—Ladies' Bridge Tea

6:45 p.m.—Dinner at Union College, University of B. C., for those attending the Student Conference

8:00 p.m.—Student Conference

RULES ON PRESENTING AND DISCUSSING PAPERS

At the technical sessions papers will be presented in abstract, 10 minutes being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 minutes are allowed each discusser. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a 5-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before Sept. 16, 1932.

* These papers are under consideration for presentation at the Pacific Coast convention, but up to date of going to press have not been officially placed upon the program.

Franklin Institute Honors Doctor Swasey

At this year's medal meeting of the Franklin Institute, May 18, 1932, Dr. Ambrose Swasey (HM'28) was awarded the Franklin Medal and certificate of honorary membership in the Franklin Institute. These are the highest honors bestowed by this organization, founded in 1824, the presentation taking place in the old hall of the Franklin Institute.

Doctor Swasey, who was honored as the inventor of a range-finding device which proved of great service during the World War, delivered an address, "Astronomers and Their Telescopes," upon this occasion. A banquet followed in the evening at the Bellevue-Stratford Hotel, at which Doctor Swasey and the recipients of other medals were guests of the Franklin Institute.

Cleveland Convention A Pronounced Success

FROM Mexico City to Saskatchewan, from British Columbia to Florida, and even from England came members and their guests to attend the 48th annual summer convention of the Institute held at Cleveland, Ohio, June 20–24, 1932. A fitting tribute to the Cleveland convention committee, and an inspiring exemplification of the sturdy qualities of the Institute and its loyal members was the record of attendance, which was 1,022. From Cleveland and vicinity the total registration was 544, and from points other than Cleveland 478. Reflecting the attractive characteristics of the convention program of technical, social, and entertainment features, the attendance this year represents some 111 per cent of the average attendance of the last 10 summer conventions and 63 per cent of the maximum ever recorded at a summer convention (Swampscott, Mass., 1,616 in 1923), figures which compare far more than favorably with those of other similar national conventions held this season. Summer convention attendance for the past 10 years has been:

1932	Cleveland, Ohio	1,022
1931	Asheville, N. C.	525
1930	Toronto, Ont., Canada	1,110
1929	Swampscott, Mass.	1,000
1928	Denver, Colo.	500
1927	Detroit, Mich.	1,200
1926	White Sulphur Spgs., W. Va.	350
1925	Saratoga Spgs., N. Y.	900
1924	Chicago, Ill.	750
1923	Swampscott, Mass.	1,616
1922	Niagara Falls, N. Y.	950

Particular credit is due the personnel of the Cleveland committees for the unqualified success of the convention and for the improvements in program brought about, through the adoption of some new features and the abandonment of some traditional activities. The many "little things" so often overlooked in the bustle of a convention were cared for in thoughtful detail.

Annual Meeting

As the opening session of the convention, the annual business meeting was held in the Ball Room of the Hotel Cleveland, Monday morning, June 20. The minutes are given in this issue, p. 522. Presided over by President Skinner, the session proved to be of considerable interest to those having at heart the affairs of the electrical engineering profession. Following introductory remarks by President Skinner, Dr. W. E. Wickenden, president of Case School of Applied Science, Cleveland, extended to the guests a most hearty welcome to the city. His manner, humorous yet sincere, was most appropriate to the occasion.

Following the presentation by H. H. Henline, acting national secretary, of an abstract of the annual report of the board of Directors, President Skinner announced the results of the recent election of officers. (See p. 517.) In his response, President-Elect H. P. Charlesworth paid tribute to the men preceding him in the highest office of the Institute, and modestly stated his desire to live up to his new obligations.

W. H. Harrison then read the report announcing the winners of Institute prizes for papers given during 1931, after which President Skinner presented the prizes. Among those receiving awards, W. H. Harrison and R. N. Conwell were the only ones present to receive their prizes at the opening session.

Unfortunately, illness prevented the attendance at the meeting of Giuseppe Faccioli, winner of the Institute's Lamme Medal for 1931; also C. C. Chesney, who was to have given the tribute to Mr. Faccioli, was not present. However, C. H. Kline (Pittsfield, Mass.) read the statements of both men, and a deep impression was created on those in attendance by the sincerity of feelings expressed in their simple remarks. In Mr. Faccioli's acknowledgment of the award he stated that, largely for the benefit of the younger engineers who might be present, he wished to emphasize the fact that "it was a pleasure—not work—for me to do the things which have won for me the Lamme Medal."

Doctor Skinner then delivered this year's presidential address, "The Institute and Its Members—Our Problems and Our Responsibilities." Printed in full in this issue of Electrical Engineering, p. 472–6, its message is of direct concern to the membership of the Institute. Following the delivery of this address, the meeting was adjourned.

Technical Sessions

Attendance at almost all of the technical sessions exceeded expectations, and in some cases exceeded arrangements which had been made for seating. The session on communication had an unusually general interest, and attracted many of the women guests. Other sessions, however, were more highly technical, and enabled the dissemination and discussion of much engineering information. At some of the meetings it was to be regretted that the lapel microphones used so successfully at previous Institute meetings were not employed. Abstracts of the summer convention papers were published in Electrical Engineering for June 1932, p. 405–13, and will not be reviewed here. However, summaries of the discussions following presentation of some of these papers will be given in subsequent issues.

A special session for the entire membership was held on the morning of June 21, at which Dr. W. E. Wickenden delivered an address, "The Engineer in a Changing Society." This address, immediately recognized by those in attendance as being remarkable for its breadth of vision in analyzing the trends of society, especially as relating to the engineer, is published in this issue of Electrical Engineering, p. 464–70. The increasing importance of the engineer in controlling the affairs of men was pointed out clearly, and encouragement given that greater social responsibility be accepted by the engineer.

Two afternoons were devoted to the conference of officers, delegates, and members

The new Mershon silver golf trophy, for match play competition, stands 27 in. high above the base and is 12 in. in diameter

usually held during the summer conventions under the auspices of the Sections committee and the committee on student Branches. A report of this conference is given in this issue, p. 522. A luncheon meeting of the board of directors of the Institute also was held, a résumé of this meeting being scheduled for a succeeding issue.

Trips and Entertainment

Cleveland's location made it particularly advantageous for the arranging of many attractive inspection trips, and all of these were very well attended. The outstanding trip, participated in by both members and guests, was the Akron-Barberton trip. This included a visit to the hangars of the Goodyear Zeppelin Corporation, and a tour of a rubber manufacturing plant attended by over 500, and dinner for 260 persons at the Mayflower Hotel, all in Akron, followed by a spectacular outdoor high voltage exhibition at the Barberton plant of the Ohio Brass Company. More than 800 witnessed this interesting demonstration. For the women, special trips and particularly appropriate entertainment features had been arranged for each day of the convention, and these proved to be very enjoyable. In the words of one woman guest, they were "priceless." The women's committee did a remarkably fine piece of work. At the Monday afternoon trip, 75 women were in attendance.

Evenings, too, were well utilized by both men and women. On Monday the president's reception and an informal dance were held; on Tuesday there was a boat trip

on Lake Erie, in which 390 participated; on Wednesday the high voltage exhibition was staged at Barberton; and on Friday there were sight-seeing and other trips available.

The peak of the unusually attractive and popular social program was reached Thursday afternoon and evening when a variety of sports, a dinner, and an old-time party were arranged for every one at the beautiful grounds of Nela Park. These provided many hours of delightful relaxation for more than 500 participants. Ball games, golf, horseshoes, swimming, and tennis were among the sporting events during the afternoon, inspection trips being conducted simultaneously through the General Electric lighting institute. Following dinner and the presentation of awards to the winners of the various events scheduled during the week, including the golf and tennis trophies, a "regular old-time carnival" together with dancing in the outdoor pavilion were provided for the evening's entertainment. After extensive deliberation and no little worry, the Cleveland committee arranged this outdoor carnival program to take the place of the almost traditional banquet. If any doubts remained as to the success of such a departure from a formal program, they certainly were decisively obliterated by the results of the experiment.

Golf

With two major trophies and many valuable prizes offered to winners of golf events, and with the long-standing Mershon tennis trophy supported by other attractive prizes for event winners, the noteworthy sports program provided for the summer convention by the Cleveland committee attracted wide attention, but merited more participants. Two prominent and highly exclusive Cleveland country clubs, Mayfield and Canterbury, graciously extended the courtesy of their facilities for the golf tournaments, while the annual tennis tournament was played on the University Club courts through the courtesy of that organization.

As announced in Electrical Engineering (Sept. 1931, p. 761) the original Mershon golf trophy, which had withstood competition since 1912, last year became the permanent property of L. F. Demming (A'11) of Philadelphia, Pa., as a result of his having twice won the right to have his name engraved on it, in 1916 and in 1931. This year, a new trophy was given by Past-President Ralph D. Mershon to be competed for by match play on a handicap basis, as heretofore, and subject to permanent possession by virtue of 2 winnings by an Institute member. The 16 men having the lowest net scores in a preliminary qualifying round were privileged to play through 4 successive elimination rounds to determine the ultimate winner.

A new trophy also was made available this year by Past-President William States Lee. This trophy will be awarded annually at the summer convention to the Institute member having the lowest net score for 36 holes, of which the first 18 may be the general qualifying round. Another innovation was the District Team event. Each District was privileged to enter a team of not more than 6 nor less than 4 players. The team having the lowest total gross score for 36 holes (4 men) was adjudged by the Cleveland sports committee as being the championship District team, and each of the 4 players on one team having the lowest total gross score for 36 holes was designated to receive a suitable individual trophy. Handicaps were based upon the 5 best 1931 scores made by the players on their regular courses, the 5 scores being averaged and the difference between that average and the par for the player's course noted. For medal play, $^4/_5$ of this difference was allowed as the A.I.E.E. tournament handicap; for match play, $^3/_4$ of the difference was allowed as the handicap.

Out of a field of 45 formal entrants, the 16 that qualified for the golf tournaments included: H. O. Anderson (A'27) New York, N. Y.; E. S. Atkinson (M'31) Battle Creek, Mich.; A. B. Cooper (M'16) and H. C. DonCarlos (F'18) Toronto, Ont., Canada; Cecil Gray (M'30) Richmond, Va.; R. A. Monroe (A'30) Pittsburgh, Pa.; G. V. Smith (M'28) Mansfield, Ohio; C. E. Stephens (M'22) New York, N. Y.; A. H. Sweetnam (M'18) Boston, Mass.; D. S. Young (A'28) Chicago, Ill.; L. M. Keating (A'22), L. R. Keiffer (A'22), G. A. Kositzky (F'29), Frank Quigley (A'32), S. B. Taylor (M'26), and C. H. Teskey (A'32) of Cleveland, Ohio. The second flight was narrowed to Anderson, Atkinson, Gray, Keiffer, Quigley, Stephens, Sweetnam, and Taylor, of whom the first four won their way into the third flight. The championship flight was fought between Atkinson and Keiffer with final honors and the Mershon Trophy going to Mr. Keiffer whose handicap was 19. The Lee Trophy was won by C. H. Teskey whose handicap of 7 gave him a net score of 143 for 36 holes against a par of 143.

The Lee golf trophy, 14 in. in diameter, for 36-hole low net. The replicas are 5 in. in diameter; one goes to each winner, whose name also is engraved on the big cup

Additional events provided for by the sports committee, and the winners of prizes therein, were:

1st low gross, C. H. Teskey, 79.
2nd low gross, G. A. Kositzky, 85.
1st low net, L. M. Keating, 72 (83 − 11).
2nd low net, A. H. Sweetnam, 73 (88 − 15).
1st blind bogey (72–88), G. V. Smith, 86.
2nd blind bogey (89–100), G. R. Canning, 96.
3rd blind bogey (101–130), G. V. Mueller, 102.

The foregoing special events were played in connection with the qualifying rounds at the Canterbury Club Monday, June 20. The following events were played in connection with Tuesday's match play at Mayfield Club:

Proximity of approach to No. 4 hole, G. R. Canning, 14 ft.
Proximity of approach to No. 17 hole, C. G. Ramsay, Manchester, England, 5 ft.
Low gross for 7 pre-selected holes, W. S. Lee, 31 (par 27).
Low net score, L. R. Keiffer, 68 (87 − 19, par 71).

Further events at Canterbury, in connection with the second flight:

Low net score, E. S. Atkinson, 70 (92 − 22, par 72).
Proximity of approach to No. 3 hole, C. G. Ramsay, 47 in.

District No. 2 (Middle Eastern) took the team competition, L. M. Keating, G. A. Kositzky, G. V. Smith, and C. H. Teskey bringing in a total gross score of 691 for 36 holes (par 572).

Tennis

With only 6 formally entered in the annual tennis tournament, the competition was not so widespread as in golf, but produced some lively sets and close scores. With the Mershon tennis trophy awaiting the winner of the men's singles the most active competition was in the singles events, although the Cleveland sports committee had prizes for the winners and the runners-up in each of the several events. With U.S. Lawn Tennis Association rules governing, all preliminary matches were decided by the best 2 out of 3 sets, the finals by the best 3 out of 5. The Mershon trophy is available to Institute members, the winner being recognized by having his name engraved on the cup and receiving a photograph of it, unless his be a second winning, in which event the cup passes permanently into his possession. With the addition of R. A. Monroe's name as the 1932 winner, the names engraved on the cup will be as follows:

1927—G. A. Sawin (M'13) East Pittsburgh, Pa.
1928—P. H. Hatch (M'29) Stamford, Conn.
1929—A. J. Gowan (A'23) St. Petersburg, Fla.
1930—E. F. Lopez (M'18) Mexico City, Mex.
1931—J. K. Peck (A'27) New York, N. Y.
1932—R. A. Monroe (A'30) Pittsburgh, Pa.

G. H. Gildersleeve (A'22) of Cleveland was runner-up; P. L. Alger (F'30) of Schenectady, N. Y., and E. F. Lopez (M'18) of Mexico City were eliminated in the semi-finals.

The Cleveland general convention committee consisted of Robert Linsay, *honorary chairman;* G. A. Kositzky, *chairman;* A. M. MacCutcheon, *vice-chairman;* G. B. Schneeberger, *secretary-treasurer;* and F. E. Snell, *Cleveland Section secretary-treasurer.* To these leaders much credit must be given for the effective planning of affairs and for many of the novel and highly successful features included. The subcommittees and the affairs for which they were responsible are as follows:

Banquet—B. W. David, *chairman*, E. W. Henderson, L. E. Knapp, C. S. Ripley, D. Schregardus, and G. V. Smith.

Entertainment—C. N. Rakestraw, *chairman*, W. H. LaMond, T. D. Owens, C. S. Ripley, and L. A. S. Woods.

Finance—G. E. Miller, *chairman*, H. J. Dible, H. Dingle, A. D. Fishel, G. H. Gildersleeve, W. H. LaMond, H. L. Martien, R. L. Rathbone, W. M. Skiff, G. E. Snider, S. B. Taylor, E. F. Whitney, and E. A. Williford.

Hotels—I. H. Van Horn, *chairman*, J. Sayre Christie, L. R. Keiffer, and W. H. Stiner.

Ladies Entertainment—Miss Deany C. LaZan, *chairman*, Mrs. L. D. Bale, Mrs. F. W. Braund, Mrs. Henry B. Dates, Mrs. B. W. David, Mrs. Howard Dingle, Mrs. C. L. Dows, Mrs. E. J. Edwards, Mrs. E. W. Henderson, Mrs. G. A. Kositzky, Mrs. J. C. Lincoln, Mrs. A. M. Lloyd, Mrs. A. M. MacCutcheon, Mrs. E. H. Martindale, Mrs. C. N. Rakestraw, Mrs. G. B. Schneeberger, Mrs. J. M. Smith, Mrs. F. E. Snell, and Mrs. I. H. Van Horn.

Meetings and Papers—J. M. Smith, *local representative.*

Publicity—E. H. Martindale, *chairman*, C. H. Bunch, F. E. Harrell, Fennel Smith, and S. B. Taylor.

Reception and Information—H. B. Dates, *chairman*, C. J. Clements, H. J. Dible, R. C. Hardy, F. E. Harrell, J. C. Lincoln, P. D. Manbeck, R. S. McIntosh, R. C. Putnam, and R. L. Rathbone.

Registration—C. L. Dows, *chairman*, R. A. Carle, W. H. Fisher, F. A. Norris, F. Von Voightlander, and Thomas Wray.

Sports—A. M. Lloyd, *chairman*, Geo. Canning, W. G. Darley, J. L. Finnicum, W. E. McFarland, L. E. Miller, C. S. Ripley, and G. V. Smith.

Technical Sessions—H. L. Wallau, *chairman*, W. E. McFarland, J. J. Pokorny, and W. C. Saker.

Transportation—F. W. Braund, *chairman*, A. D. Fishel, G. H. Gildersleeve, H. T. Killingsworth, G. H. Mills, and C. E. Winegartner.

Trips—L. D. Bale, *chairman*, J. Callahan, Arthur Eastman, M. R. Gowing, C. A. Harrington, R. A. Hudson, A. H. Nicholson, and H. W. Pinkerton.

Outline of Minutes of 1932 Annual Meeting

With President C. E. Skinner presiding, the annual meeting of the American Institute of Electrical Engineers was held at the Hotel Cleveland, Cleveland, Ohio, as the opening session of the annual summer convention, Monday morning, June 20, 1932.

The annual report of the board of directors was presented in abstract by H. H. Henline, acting national secretary. Printed copies were distributed to members in attendance and are available to any member upon application to Institute headquarters, New York, N. Y. The report, which constitutes a résumé of the activities of the Institute during the fiscal year ending April 30, 1932 shows a total membership on that date of 17,550. In addition to the 3 national conventions and 2 District meetings, 1,632 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States, Canada, and Mexico. The report will appear in full in the quarterly TRANSACTIONS of the Institute.

The report of the committee of tellers on the election of officers of the Institute was presented, and in accordance therewith President Skinner declared the election of the following members taking office August 1, 1932:

President:

H. P. Charlesworth, vice-president, Bell Telephone Laboratories, Inc., New York, N. Y.

Vice-Presidents:

J. Allen Johnson, chief electrical engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.

E. B. Meyer, vice-president, United Engineers & Constructors, Inc., Newark, N. J.

K. A. Auty, sales engineer, Commonwealth Edison Company, Chicago, Ill.

G. A. Mills, chief engineer, Central & South West Utilities Company; vice-president, Pecos Valley Power & Light Company, Dallas, Tex.

C. R. Higson, superintendent of distribution, Utah Power & Light Company, Salt Lake City, Utah.

Directors:

G. A. Kositzky, chief engineer, The Ohio Bell Telephone Company, Cleveland, Ohio.

A. H. Lovell, assistant dean and professor of electrical engineering, University of Michigan, Ann Arbor, Mich.

A. C. Stevens, in charge, educational sales, General Electric Company, Schenectady, N. Y.

National Treasurer:

W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

The board of directors for the next administrative year, beginning August 1, 1932, will consist of these officers, together with the following hold-over officers: C. E. Skinner (retiring president), East Pittsburgh, Pa.; W. S. Lee, Charlotte, N.C.; W. B. Kouwenhoven, Baltimore, Md.; W. E. Freeman, Lexington, Ky.; P. H. Patton, Omaha, Neb.; A. W. Copley, San Francisco, Calif.; L. B. Chubbuck, Hamilton, Ont.; J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; R. H. Tapscott, New York, N. Y.; L. W. Chubb, East Pittsburgh, Pa.; B. D. Hull, Dallas, Tex.; H. R. Woodrow, Brooklyn, N. Y.

President Skinner then congratulated President-Elect Charlesworth upon his election and presented him with the president's badge. Mr. Charlesworth responded with a brief address, which was enthusiastically received.

The report of the committee on award of Institute prizes, as published in the June 1932 issue of ELECTRICAL ENGINEERING, p. 418 was read by W. H. Harrison, chairman of the committee of award, after which the prizes were presented by President Skinner.

The Lamme Medal for 1931, which, as announced in the March 1932 issue of ELECTRICAL ENGINEERING, p. 209, had been awarded to Giuseppe Faccioli (A'04, F'12) of Pittsfield, Mass., was presented.

The annual presidential address then was delivered by President Skinner. (See p. 472–6.)

Adjourned.

(*Signed*) H. H. HENLINE
Acting National Secretary

Officers, Delegates, and Members Hold Conferences in Cleveland

ON Monday and Tuesday afternoons, June 20 and 21, 1932, the conference of officers, delegates, and members of the Institute was held at Cleveland, Ohio, as part of the recent summer convention. This conference was under the auspices of the Sections committee and the committee on student Branches. Present at this conference were delegates from 49 of the 60 Sections, 9 of the 10 District secretaries, and counselor delegates from 7 of the 9 Districts in which committees on student activities have been organized, as well as officers, officers-elect, and other members.

After a brief opening session on Monday afternoon, sessions A and B were held in parallel E. S. Lee, chairman of the Sections committee, presiding over session A devoted to Section activities, and Prof. W. H. Timbie, a chairman of the committee on student Branches, presiding over session B which dealt with problems concerning the Branches and Enrolled Students of the Institute. Tuesday afternoon was devoted to a joint meeting of the two groups to discuss subjects of common interest.

The topics in a conference program, which had been mailed to delegates and others in advance, are given in the following outline:

Monday, June 20, 2:00 p.m.

1. Opening of Conference: Announcements by Everett S. Lee, Chairman of the Sections Committee
2. Remarks by President C. E. Skinner
3. Remarks by President-Elect H. P. Charlesworth
4. Remarks by Acting National Secretary H. H. Henline
5. Division into parallel sessions of Section and Student Branch delegates and members

Session A—Section Meeting—Everett S. Lee Chairman

6. Making the Institute of even greater value to the individual member
   a. The advantages of Institute membership—Everett S. Lee
   b. How the membership committee brings these advantages to the attention of prospective members—R. L. Kirk
   c. How the publications of the Institute maintain membership—E. B. Meyer
   d. How the committees of the Institute maintain membership—Prof. W. B. Kouwenhoven

e. How the Sections of the Institute maintain membership—J. J. Shoemaker
f. Problems of the finance committee—C. E. Stephens

Intermission

Discussion

Session B—Student Branch and Enrolled Student Meeting—Prof. W. H. Timbie, Chairman

7. Methods of teaching "Safety" to students
8. Organization of engineering clubs in local high schools—Prof. J. T. Walther and F. C. Young
9. Is it advisable to make student attendance at Branch meetings compulsory?
10. Suggestions for improving ELECTRICAL ENGINEERING
11. Suggestions for securing delegate representation for Branches located in Districts having fewer than 3 Branches
12. Student participation in District conventions—C. E. Baugh
13. Nature and content of program—Prof. M. S. Coover
14. Should some organization similar to Student Branches be set up in trade and industrial schools? —Prof. W. J. Seeley
15. Approved list of engineering colleges—G. L. Weller
16. Cannot the customary appropriations from headquarters to Student Branches be paid in advance as is done in the case of Sections?

Tuesday, June 21, 2:00 p.m.

Session C—General—Everett S. Lee, Chairman

17. The professional status of the engineer—Prof. C. F. Scott
18. Legislation affecting the engineering profession—L. W. W. Morrow
19. Special committee on Institute policies—C. E. Stephens

Discussion

Intermission

20. Section and Branch cooperation
21. The coming year—H. P. Charlesworth

Copies of the annual report on Section and Branch activities for the fiscal year ending April 30, 1932 were distributed. These may be secured without charge to Institute members by applying to headquarters.

As indicated by the program, many subjects of great importance to the Institute were discussed. At the Section meeting, considerable attention was devoted to the matter of transfers, while at the student Branch and Enrolled Student meeting, much encouragement was given the formation of engineering clubs in high schools and the matter of providing talks before high school groups to be given by prominent and capable engineers.

RECOMMENDATIONS ADOPTED

The principal recommendations to the board of directors which were adopted are summarized briefly as follows:

1. Clarification of the relations between Associate and Member dues and the requirements for admission to the grade of Member.
2. Joint action by the Institute and other engineering societies to encourage the formation of engineering clubs in high schools.
3. The publication of one "feature article" in each issue of ELECTRICAL ENGINEERING.
4. The submission, by Institute headquarters to geographical District committees preparing for District meetings, of certain definite suggestions regarding the formation of a sub-committee to prepare for a student session and to make suitable arrangements for all phases of student participation in the meeting.

All of these recommendations were considered at the meeting of the board of directors held on June 22, and the following actions were taken (the numbered paragraphs refer to the corresponding recommendation):

1. Appointment of a special committee was authorized.
2. Referred to Institute representatives on the conference on certification into the engineering profession.
3. Referred to the publication committee.
4. Approved.

An abstract of the proceedings of the entire conference will be printed in pamphlet form and mailed to all delegates present; also to Institute, Section, and Branch officers. Any member of the Institute may secure a copy without charge by applying to headquarters.

Lamme Gold Medal for 1931 Awarded

FORMAL presentation of the Lamme Gold Medal established by provision of the will of Benjamin Garver Lamme (deceased July 8, 1924) for the encouragement and recognition of "meritorious achievement in

the development of electrical apparatus or machinery" took place June 20, 1932 at the annual business meeting of the A.I.E.E. during the summer convention at Cleveland, Ohio, with GIUSEPPE FACCIOLI (A'04, F'12) retired associate manager of the Pittsfield (Mass.) works of the General Electric Company, medalist for 1931. Mr. Faccioli (see p. 209, ELECTRICAL ENGINEERING, March 1932) was chosen to receive this award "for his contributions to the development and standardization of high-voltage oil-filled bushings, capacitors, lightning arresters, and numerous other features in high voltage transformers and power transmission." The first A.I.E.E. award of the Lamme Medal, made in 1928, was to A. B. FIELD (A'03, F'13) consulting engineer, Manchester, Eng., subsequent medals going to R. E. HELLMUND (A'05, F'13) chief electrical engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and W. J. FOSTER (A'07, F'16) consulting engineer, retired, General Electric Company, Schenectady, N. Y.

By Mr. Lamme's will, two other similar bequests were made, one to Ohio State University, the recipients of this medal to be a graduate or graduates of any of the university's engineering branches and the award to be "for meritorious achievement in engineering or the technical arts." The Lamme medals of Ohio State University will be presented this year to A. V. BLEININGER, chemist to the Homer Laughlin China Company, and to R. D. MERSHON (A'95, F'12 and past-president), consulting engineer and chemist, New York, N. Y.

Junior Engineers Plan Industrial Projects

An interesting project program for junior members has been carried on successfully for some time by the Western Society of Engineers of Chicago, Ill., and more recently was taken up actively by the Cleveland (Ohio) Engineering Society. Junior members of these societies have organized themselves into fictitious holding, construction, and operating companies, and as such will undertake to solve the various problems that confront a typical industrial organization in undertaking new or enlarged operations including new manufacturing plant facilities.

The fundamental idea of the activity, as far as the societies are concerned, is to provide a continuity of interest in their junior member programs and to make these programs of definite interest and value to the junior members by giving the maximum number a definite responsibility in the various projects. The juniors consulted local firms having to do with the design, erection, and equipment of industrial buildings, and obtained from such firms the original specifications which had been given to the firm by the owners of a typical industrial project. With these plans in hand the junior members of the societies organized themselves into the necessary hypothetical finance, construction, and operating companies with related subsidiary units to study the various problems involved.

The junior members sent in formal "applications" for positions in the hypothetical companies outlining their qualifications, etc. The junior personnel of the various "companies" and "departments" will handle all of their own investigations, analyses, and design and operating problems, and will follow the work through to a complete "plant" design to meet economically the production and marketing requirements as determined by the various studies. After these plans have been completed they will be checked, through the courtesy of the local firms, against the actual solutions to the original problems, and against the actual plants themselves.

These activities seem to have aroused great interest among the junior members of both the Chicago and the Cleveland societies, and it seems probable that many of the Student Branches of the Institute might, to advantage, undertake similar projects with the helpful cooperation of related local sections.

Summarized Review of Some Providence Meeting Discussions

PRINCIPAL discussions of Providence District meeting papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for April 1932, p. 263–7.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

PARALLEL-TYPE INVERTER

W. M. Goodhue (Cambridge, Mass.) described experiments which showed that static condensers may be omitted also when the a-c. line is replaced by a salient-pole damper winding synchronous motor. A 6-phase circuit with 6 thyratrons was used because it was preferable to operate the motor polyphase. The grids were excited by a polyphase induction phase-shifter consisting of a slip-ring induction motor with the rotor turned by a handwheel and worm drive, and insulating transformers for the rotor output. This phase-shifter was supplied directly from the terminals of the synchronous motor so that the inverter was permanently locked in step with the motor, and would automatically follow any speed changes. It was explained that the synchronous motor took load up to the maximum rating of the tubes, and showed no tendency to hunt or to fall out of step even when the shaft load was suddenly changed.

ELECTRIC AND MAGNETIC UNITS

L. C. Eddy (Riverside, R. I.) believed that the general relations of units presented in the paper might prove to be of ultimate value for more thoroughly understanding universal relations of even certain forms of life. Both radio-activity and magnetism depend on certain relations or numbers of electrons or atoms much as animal life itself appears mainly where carbon is present in more or less definite relations with other elements.

PERFORMANCE CALCULATIONS ON INDUCTION MOTORS

H. R. West (Pittsfield, Mass.) discussed this subject and advocated using a method of calculation which would give the desired accuracy with the least labor. He believed that the results of algebraic analyses, arranged in systematic form such as Mr. Veinott is using, could be used more profitably than they are at present.

R. E. Hellmund (East Pittsburgh, Pa.) discussed and explained why the discrepancy between the results obtained from load tests and those obtained by calculating methods from no-load values and other motor constants has been greater than it was 20 years ago. The up-to-date motors with smaller dimensions have higher flux densities and also more ampere conductors within a unit of space than was found in the earlier ones which most likely means in general more ampere conductors per slot than in the older designs. Then the zigzag and slot leakage fluxes would increase, tending toward greater saturation at load, especially in the tooth tips of partially closed slot machines. Since all theories deriving motor performance from the motor constants neglect the effect of saturation, he explained it was not surprising that in the modern designs there should be a greater discrepancy between such calculated results and tests made under actual load conditions.

P. C. Smith discussed several points in this paper and he believed the method permitted quick approximations or accurate calculations as desired. He questioned, however, the influence of friction and windage on the current through the shunt circuit and he did not believe that core loss always decreased with the load. In the determination of secondary loss in cases where the actual slip was available, he believed it might be advisable to substitute this for the secondary resistance.

Another discussion by P. H. Trickey (Springfield, Mass.) stated that he had used the author's method of calculation for over a year for both single-phase and polyphase motors rated between 2 hp. and 3 watts output and obtained very satisfactory results.

STRAY-LOAD LOSS IN INDUCTION MOTORS

O. C. Rutledge (New Haven, Conn.) compared the results obtained in the paper by placing them on a percentage basis taking the input-output method as 100 per cent for each case. His analysis showed that method *A* gave low values while methods *B* and *C* gave permissible average values but there was a considerable spread from minimum to maximum. Mr Rutledge also presented curves obtained from tests on a 10-hp. wound rotor machine. Comparisons of both the input-output and direct methods were shown in curves plotted for loss against line current. These curves indicated that in the vicinity of full load the loss by direct measurement is of the same order of magnitude as that by input-output determination. However, the shape of the curve still left open the question as to whether or not the pulsation loss by the d-c. method is a correct representation of the true pulsation loss under load.

Messrs. O. C. Schoenfeld and S. F. Henderson (East Pittsburgh, Pa.) discussed the paper and they believed the method outlined had some merits although not theoretically correct nor could they check it experimentally. In their opinion proper consideration had not been given to the effect of saturation which could have considerable influence and as a result the d-c. short-circuit method gave values in excess of those obtained under normal load conditions. A tabulation of their tests showed full load efficiencies and stray load losses for 6 motors. The results indicated that the method proposed did not give sufficiently accurate results and the conventional efficiency in several cases gave results closer to the input-output value although the error was in the opposite direction. In general, the correction factors proposed by Linckh were correct but, as they were based on only a few tests, they should be further checked. In conclusion, the discussers did not believe that the method proposed simplified facilities or shortened time testing.

L. E. Hildebrand (Lynn, Mass.) also discussed this subject and cited the difficulties with present test methods. He believed that in all practical work a conventional efficiency test including a conventional load loss is certainly superior to ignoring load loss. Also this test with an average crew and equipment should be superior to the impractical input-output test providing a method is used for determining a conventional load loss which gives consistently repeatable results approximately equal to the true load loss. It was believed that such a method should be legalized and that the author's method *D*, with *C* as a permissible alternative for single-cage motors, seemed practical for a tentative permitted method.

Another discussion by H. L. Barnholdt (East Pittsburgh, Pa.) took exception to the proposed method *D* for squirrel-cage induction motors because only one test was indicated comparing this method with the input-output test. While this checked quite closely it was believed that, if a number of tests were made, they might show as wide discrepancies as methods *A*, *B*, and *C*. Further tests and greater consistency of test results were suggested as necessary before attempting standardization. The discusser also suggested an arbitrary allowance, say 3/4 per cent, to cover stray-load losses on large induction motors. Input-output tests could be made when opportune so as to revise the allowance.

Still another discussion on this subject by C. G. Veinott (East Pittsburgh, Pa.) commended the author for his endeavor to measure the stray-load loss in polyphase induction motors. He thought the paper brought out reasons why the Institute should make a distinction between large and small motors and should, in his opinion, recommend the directly measured efficiency (input-output method) for the small motors. This opinion was based on the importance of stray-load losses in small motors and the ease, cheapness, and reliability of the input-output method. It was believed the dividing line between methods should be in sizes above 3 hp.

P. L. Alger (Schenectady, N. Y.), chairman of the committee on electrical machinery, discussed this subject as follows:

"The general opinion expressed was that, while it is very desirable to establish a standard method for determining induction motor load losses, and while Mr. Koch's proposals are fundamentally sound, much yet must be done in the way of study and tests before any method can be adopted as a standard.

"There was general agreement that measurement of the rotational losses by driving the motor at normal speed with direct current in the stator winding is an essential element in any direct measurement of stray-load loss. A difficulty arises, however, in the determination of the correct secondary I^2R loss to be subtracted from the total rotational losses.

"If the rotor I^2R loss is determined on the basis of the resistance corresponding to normal load slip, the value obtained is too small, since it does not include the full frequency rotor iron and copper losses.

These errors are very large on deep bar or double squirrel-cage motors, and for this reason methods B and C are regarded as undesirable for general use.

"While determination of the rotor losses by measurement of the standstill torque at full load current almost gives theoretically correct results, it is very difficult to carry out in practise on small motors, because of the irregularity of the torque position curve and the errors due to bearing friction.

"Determination of the rotor losses by measuring the impedance watts input and subtracting from it the primary I^2R loss is convenient and approximately correct in the case of overhung slot motors, but it gives a value of rotor loss which is slightly too large, and, therefore, gives a value of stray-load loss somewhat too small. This error is somewhat offset by the existence of saturation in the flux leakage paths under normal load conditions. It seems practical, therefore, to get accurate results by this method, if a simple correction factor of perhaps 10 per cent is applied to the primary copper loss.

"In conclusion, method A should form the basis of standards for stray-load loss measurement in the case of overhung primary slot motors of one hp. and larger, with the addition of a multiplying factor of perhaps 1.1 for the primary copper loss on the standstill impedance test. Method D should form the basis of standards for stray-load loss measurement in the case of open primary slot motors (which are generally built in ratings of 20 hp. and larger). Direct input-output tests should remain standard for fractional hp. motors and should remain optional for larger motors.

"The induction motor subcommittee of the committee on electrical machinery is now reviewing this problem, and plans to submit some definite recommendations on the subject to the standards committee in the near future."

Synchronous Machine Characteristics

J. W. Butler (Schenectady, N. Y.) discussed this subject and analyzed mathematically the calculation of damping torque for comparatively large sustained oscillations. He also emphasized the equivalent circuit shown in Fig. 9 of the paper which can be used to calculate any sort of a transient in a machine, including resistance, within the assumptions made. One particular use which was made of the circuit was in calculating decrement curves, for a fault on a generator feeding an impedance load, considering the effect of the load resistance in the time constants and magnitudes of the current.

In connection with this subject (S. H. Wright) cited certain prime advantages of low and high resistance dampers. Low-resistance dampers, he explained, tend to rapidly damp out swings which occur during symmetrical circuit conditions. For 2-machine stability problems, or multi-machine problems, where there are no serious compound oscillations, high resistance dampers give higher transient stability limits, especially for the longer clearing times, such as greater than 16 cycles where $f = 60$ cycles per sec. However, in the future, clearing time will probably be reduced to 8 cycles or less; interconnections and other factors will make compound system oscillations more important, so that greater damping ability, under symmetrical circuit conditions, of low-resistance dampers would become of paramount importance.

Capacitor Motor Design

L. A. Doggett (State College, Pa.) questioned the theory of the capacitor motor developed on the assumption of sine waves. An oscillogram of current waves taken when a capacitor motor running light was operating from practically a sinusoidal source showed values 4.4, 6.1, and 2.4, respectively, for line current, capacitor-phase current, and main-phase current. The wide departure of these currents from sinusoidal shape throughout the whole range of operation was brought out by an I^2R, I^2X analysis of the load run test data. The wide discrepancies in tabulated I^2X values was believed to indicate the presence of large harmonics.

P. L. Alger (Schenectady, N. Y.) commented on several points of L. A. Doggett's discussion. In his opinion the discussion was incomplete, when it simply pointed out the presence of harmonics and questioned the validity of the theory which neglects them, without some figures showing the actual magnitude of the errors they may introduce. If the ratio of the actual to the assumed sinusoidal copper losses were calculated from the test oscillograms, the results presented would be more interesting. In reference to the comparison of line I^2X with those of the 2 branches the discusser pointed out that 3 out of the 9 cases checked closely and he believed that discrepancies in the other cases could be due to the inaccuracies inherent in the calculation from observed values of voltage, current, and watts.

Another discussion by C. G. Veinott (Springfield, Mass.) brought out that this paper showed the conditions which must be met in order to obtain operation equivalent to that of a 2-phase motor and incidentally brings to light important conclusions. For example, Fig. 1 in the paper showed that the ratio of capacitor phase turns to main-phase turns was of the order of the tangent of the power-factor angle of the motor when considered as a 2-phase motor with both phases like the main winding. It is, therefore, necessary to have control of the winding ratio as well as the external microfarads in order to obtain balanced operation. Consequently any polyphase motor cannot necessarily be operated as a polyphase motor from a single-phase source merely by the addition of a capacitor of suitable value in one phase.

Multiple Conductors

In connection with this subject Dr. Hillel Poritsky (Schenectady, N. Y.) described the method in which he obtained the exact solution for the maximum potential gradient of 2 cylinders having charges equal in magnitude and of the same sign. This required doubly periodic or elliptic functions for its treatment and the formula obtained is applicable to determine the critical disruptive voltage of a double conductor transmission circuit.

S. B. Crary (Schenectady, N. Y.) discussed the comparison of maximum potential gradient obtained by approximate and correct formulas for the case of multiple conductors with charges of equal magnitude and the same sign. He explained that for practical cases eq. 5(c) in Miss Clarke's paper was developed. This formula corrects for the field distortion due to the conductors of the same phase by making 2 assumptions. First, the field distortion due to the conductors of the other phases and the ground plane is negligible. Second, the field produced by the other conductors of the same phase may be considered uniform in the region of the conductor under consideration. The accuracy obtained by using this approximate eq. 5(c) was shown graphically compared with the results obtained by using Dr. Poritsky's formula. It was essentially correct for a ratio of spacing to conductor diameter as low as 5 to 1. Another curve showed that if field distortion were neglected for this ratio it would have resulted in an error of 15 per cent.

Another discussion by W. W. Lewis (Schenectady, N. Y.) considered the economical aspects of the problem. He pointed out that the large weight of conductors required heavy towers and short spans. Also to obtain continuously decreased reactance, increased capacitance, and increased corona starting voltage, it was desirable to maintain as closely as possible the spacing between conductors in the same phase and in the different phases. This would require special insulating arrangements and supporting and separating yokes which would increase the expense. The discusser gave cost data compiled as a result of a comparative study of split conductor 345 kv. and 230 kv. lines as compared with conventional lines of the same voltage. From these data it appeared that at 345 kv. the 2 conventional lines had about the same cost per kv. and same yearly charge as one split conductor line. However, 2 conventional circuits have a greater total capacity and have the obvious advantage that the total flow of power is not dependent upon one tower line. At 230 kv. the comparative costs and yearly charges were about the same; however, the conventional lines had a considerable margin of greater capacity.

W. S. Moody (Pittsfield, Mass.) also discussed this subject in relation to the suggested methods of obtaining the reactive voltage by the use of transformers having very high magnetizing current resulting from the use of air gaps in their magnetic circuit or separate reactances distributed along the line. He explained that even the slight air gaps commonly used in European transformer practise have proved a very troublesome feature and they are gradually being dropped for our interleaved core construction. The 4 very long gaps required would drive a very heavy flux into the winding space of the transformer. This would necessitate very small conductors to avoid excessive eddy losses in them and would thus greatly weaken the windings mechanically. The varying density of the flux along the wire space also would create great difficulty in a parallel connection of any portion of the windings. Therefore, distributed loading coils would be preferable to obtain the necessary reactive voltage.

Plans to Proceed for Colorado River Aqueduct

Information has been received from California to the effect that the Supreme Court of California rendered a decision on June 2, 1932, that the bonds for the construction of the Colorado River aqueduct are valid. These bonds total $220,000,000 and were authorized by the 13 cities composing the metropolitan water district of southern California on September 29, 1931. The purpose of the bonds is to finance an aqueduct to supply the Los Angeles metropolitan area with water from the Colorado River.

The main aqueduct will be 240 miles long. Storage facilities for regulating the flow will be provided, as well as distribution lines for delivering the water to the existing systems in the cities of the metropolitan water district. Power for pumping will be secured principally from the government plant at Hoover Dam, supplemented by smaller amounts at various parts of the system. The total static pumping lift will be 1,583 ft. It is contemplated that an average flow of 1,500 sec.-ft. will be diverted from the Colorado River and carried over the high lands to the Los Angeles basin.

At present it is planned to construct a diversion dam to raise the water surface 72 ft., creating a reservoir of 716,000 acre-ft. capacity. An opportunity also is afforded for the development of 80,000 kw. of electrical energy.

Although this great project will require the employment of a large force of men, a word of warning has been expressed to discourage large numbers of men coming to the district in the hope of securing work. It is stated that men are now available in southern California in excess of all requirements for every opening that the aqueduct work can possibly afford for months to come.

Radio Study in Copper Country.—Amateur short wave radio station W9YX and W9XAW at the Michigan College of Mining and Technology, Houghton, Michigan, was opened in January 1931. Since that time experiments in radio transmission have been conducted, consisting largely of attempts to determine what type of transmitters and aerials are best suited to the station's locality, the Michigan copper country. The most difficult problem is to overcome the great day-to-day variation in range of consistent communication. Receptivity has been found to vary, although it changes less than the transmission range. The staff at the Michigan college has tested Hartley and tuned-plate, tuned-grid transmitters and modifications which it has devised. Satisfactory communication was established March 1, 1932 with the present set consisting of a 100-watt tuned-plate, tuned-grid transmitter for continuous wave work, and a low power 7.5-watt phone set. The station operates on 40 and 80 meters. Aerials experimented with have variations or modifications of the Hertz antenna, vertical types of Zeppelin, horizontal Zeppelin, and single-wire-fed matched impedance. In February 1932 the staff returned to the voltage-fed Hertz type used earlier. The next experiments will consist of studying the efficiency of ultra short wave lengths of from 3 to 5 meters.

A Tribute to Frank J. Sprague

A meeting of appreciation and tribute to Frank J. Sprague (A'87, F'12, HM'32 and past-president) is to be held Monday, July 25, 1932, at 8 p.m. in the Engineering Societies Auditorium, 33 West 39th Street, New York, N. Y. Doctor Sprague, engineer, scientist, and inventor, is to be honored on the seventy-fifth anniversary of his birth for his long service to industry.

F. J. SPRAGUE

(Electrical Engineering for February 1932, p. 139–40 outlined the achievements of Doctor Sprague, a pioneer in electrical applications, principally of electric motors, railways, and elevators.)

The meeting is being held under the auspices of the Frank J. Sprague anniversary committee, Gano Dunn, *chairman*, and C. T. Hutchinson, 52 William Street, New York, N. Y., *secretary*. Presidents and secretaries of the leading engineering and related societies, as well as a large group of other prominent individuals, are assisting the committee. The program for the meeting is as follows:

"An Engineer's Contribution to the World's Welfare," Dr. John H. Finley.

"An Engineer's Contribution to Transportation," Frank Hedley.

"Frank J. Sprague—A Tribute," Rear Admiral S. S. Robinson, U.S.N. (Ret.).

Response: Frank J. Sprague.

Members of the assisting societies and friends are invited.

An all-welded condenser, reputedly the largest of its kind ever built, is one of the principal features of interest in the newly enlarged Kearny, N. J., steam-electric generating station of the Public Service Electric and Gas Company. The condenser contains 11,900 24-ft. tubes, and, with an expected water rate of 105,000 gal. per min., it is expected to handle the 780,000 lb. of steam per hr., required by the newly installed 75,000-kw. turbine generator set, the recent completion of which is reported as increasing the capacity of the Kearny station from 214,500 to 289,500 kw.

Elevators for Carlsbad Cavern

To eliminate a 750-ft. climb that formed an irritating but necessary part of a visit to the major features of the Carlsbad Cavern, N. M., the national park service has provided a passenger elevator by which tourists are taken to the main level of the cave. The development consists of providing a high-speed passenger elevator of modern design and safety equipment in a shaft drilled simultaneously from top and bottom through 754 ft. of rock to the main cavern level. The cavern in this national park contains the largest series of underground caverns ever explored, extending through 50 miles of known chambers and corridors.

The shaft size was 6 ft. 10 in. x 14 ft. 3 in. inside the concrete lining. The shaft was lined with gunite varying in thickness from $^1/_4$ in. to several inches. The elevator, house, shaft, and guide construction are entirely fireproof, with guide-rail supports of *I*-beam sections set into the rock walls.

The steel headframe is the center of a 3-story shaft house. The first floor is occupied by the elevator landing, the second floor is used as a generating room, and the third contains the machinery and controls. The roof will be used as an observation gallery. A novel feature of this building will be the provision for natural heating, cooling, and ventilation, using air from the cavern, which is always at a temperature of 56 deg.

The elevator is of modern electric type with self-leveling cage carrying 12 persons. It is planned to operate at a speed of 700 ft. per min. One elevator has been installed at the present time, and a second will be added later in the other compartment. With the exception of a few of the elevators in the Empire State Building, the present installation is the longest single-lift passenger elevator in the world. The equipment contains all automatic safety devices found in usual building installations.

—Excerpts from an article by F. A. Kittredge and W. G. Attwell, appearing in *Engineering News-Record*, June 9, 1932.

Philadelphia Engineers Are Helping Each Other.—An organization has been formed of unemployed engineers, who, true to their vocation, are doing their bit toward keeping up the morale of their fellow engineers, and serving industry by helping it in securing competent technical help. This organization is the technical service committee of the Engineers' Club of Philadelphia, Pa., located at 1317 Spruce St. The committee is an association of 12 national engineering societies, and its cooperation with the state employment commission makes it an organization of permanence. A very complete group of 850 highly technical men is ready to fill any gap that may exist in an organization. As stated by the committee, it is well worth noting that these technical men are plentiful now, but when the pendulum begins to swing upward again they will be scarce, and the employers who will take advantage of this opportunity now will have the most stable organization when business is back to normal.

Letters to the Editor

Eliminating Transients in D-C. Welding Generators

To the Editor:

In addition to the interesting papers by Messrs. S. R. Bergman ("Transforming Reactor Improves D-C. Arc Welding," ELECTRICAL ENGINEERING, April 1931, p. 283–5) and by J. H. Blankenbuehler ("An Improved Welding Generator," ELECTRICAL ENGINEERING, August 1931, p. 666–8) and the "Letter to the Editor" by C. J. Holslag ("Characteristics of Arc Welding Generators," ELECTRICAL ENGINEERING, January 1932, p. 59) let me point out that I was probably the first to suggest the application of static transformers to d-c. generators supplied with multiple fields (separately excited and series fields for instance), in order to obviate the undesirable transients. In 1911, I took a French basic patent number 444,322, assigned to the "Société Alsacienne de Constructions Mécaniques," and some time later, the same idea was applied by R. Thury to high tension d-c. generators for constant current power transmission.

More recently, I patented the special application to arc welding generators, and in 1927 a full description of such improved generators was published in "Bulletin de la Société Alsacienne de Constructions Mécaniques" April 1927, p. 45; since 1928, they have been built by the French company "Als-Thom." Some years ago, complete information was given to American firms, but they were not interested in acquiring rights under my invention.

Very truly yours,
J. BETHENOD (A'18)
(Consulting Engineer, 48 Quai d'Auteuil, Paris, France)

Propagation Constant of a Transmission Line

To the Editor:

In the February 1932 issue of ELECTRICAL ENGINEERING, p. 128–9, appeared an article by W. J. Creamer, Jr., "Propagation Constant of a Transmission Line" in which the author summarizes his problem and results thus: "The propagation constant of a transmission line usually is developed by means of differential equations...... A derivation of this constant which depends only on the application of Kirchhoff's laws and simple hyperbolic trigonometry is given below." I have the following comments to make:

1. There is nothing new in the method used by the author. Steady-state transmission theory in general may be and has been derived by the method used in the paper.

2. In deriving the result the author introduces an approximation which is unnecessary and is usually not made in deriving the propagation constant by this method.

In support of these comments, reference can be made to "High Frequency Alternating Currents" by Knox McIlwain and J. G. Brainerd, in which eq. 190 is the same as eq. 3 of the paper except that voltages rather than currents have been used; eq. 191 is the same as eq. 4 of the paper, and the derivation of the propagation constant of a line, as given on page 318, of the abovementioned text-book, is more exact than that given in the paper. Incidentally it should be noted that the authors of the text-book cited clearly state that the material is not original, and indeed the method used in the paper is a relatively old one, known to antedate the text by some years.

Very truly yours,
H. C. HART
(Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.)

Savings and Investment

To the Editor:

According to the Progress Report of the American Engineering Council ("The Relation of Consumption, Production, Distribution," ELECTRICAL ENGINEERING, June 1932, p. 373–9), the principal cause of a business depression is that savings are made at a rate faster than investment. Such a statement needs a word of explanation. The true measure of savings is the amount of goods in existence. All that exists now has been saved from some past time, possibly saved for only a few minutes, or possibly for thousands of years, but it all has been saved. Investment consists of saving in some form that will yield a profit. When a man saves his old clothes to do dirty work in, that is saving but not investment. The excess of saving over investment literally refers principally to that type of saving. Yet it is perfectly evident that the committee had some entirely different idea in mind.

The report suggests that it is referring to money, that when the community as a whole takes in more money than it spends either for consumption of goods or it places in investment, then we have a depression. This appears to be the thought behind the report, but a little consideration is enough to show that the community cannot possibly do anything of the kind. Mr. Brown has a hat and Mr. Smith $3. Mr. Smith may keep the $3 and Mr. Brown keep the hat, or they can trade so that Mr. Brown will have the $3 and Mr. Smith the hat, but the money is saved just the same. It is still saved by some one, no matter how many times it is spent. All the money issued is saved, and no more can be saved, no matter what is done in business.

Possibly the hoarding of money is referred to. There are times when money is hoarded in unreasonable amounts, but there is no reason to think that money was so hoarded in 1929. That seems to have been a time of free spending rather than hoarding. Money hoarding has been blamed for many things, and it doubtless has caused some damage, but evidence that it is a major factor in the business cycle is entirely lacking.

It is hard to tell what the committee had in mind when it referred to the excess of savings over investment. We cannot take the words in their strict literal meaning. That would produce a result evidently absurd. We cannot take them to mean saving money, for the community as a whole cannot change the amount of money saved. I cannot think of any interpretation of the statement that will stand examination on sound principles of economics. But whether the committee is advocating a sound or unsound economic program, when they use a statement as the foundation on which their reform program is based, this statement should at least be expressed so that there would be no doubt as to its meaning.

Very truly yours,
A. W. FORBES (A'12)
(Forbes & Myers, Worcester, Mass.)

Injuries From Electric Shock

To the Editor:

I have read with considerable interest over the period of the past few months, the comments in "Letters to the Editor" in connection with the published results of Doctor Kouwenhoven's researches on electric shock, particularly the protests of our anti-vivisectionist members.

There can be no question but that these protests are in good faith and registered in a sincere belief that the taking of life for any purpose is wrong; however, this is no place to argue the merits and demerits of surgical experiments upon living specimens. I would like to state myself definitely on the relation of electric shock to electrical engineering as a profession.

Cases of electrical shock are almost without exception the natural result of the increased use of electrical power, they usually have as a victim a person directly connected with the electrical industry, the discoverers of a victim of electric shock are in nearly all cases employees of the electrical industry and as such would administer efforts at resuscitation, and last but not least, the only individuals, with but few exceptions, who appear to have any interest in combating the results of electric shock are the insurance companies and the electrical industries.

The question of improved procedure and methods of relieving persons of the consequences of electric shock is of as much importance to the electrical industry, and the world, as is the problem of building surge-proof transformers, and the protection of transmission lines from flashovers, not only from a humanitarian point of view but also from the commercial standpoint. Improved safety devices and insulation standards have greatly lowered the hazards of the electrical worker, but there will always be found in experimental work and construction projects a comparatively high possibility of death from electrical injury. And the possibility of saving a few of these lives through knowledge gained through experiments with animals is worth all of the rats of Hamlin, and more.

Whether or not these results should be published in the issues of ELECTRICAL ENGINEERING can have but one answer. We of the electrical industry have no one but ourselves to protect us against electric shock; everything possible is done in the way of safety standards, but carelessness and chance are ever ready to take their toll. It is, therefore, left to us to forward and encourage in every possible way responsible research on electric shock and the prevention of death thereby, and that means both financial support and the publication of results.

Very truly yours,
F. W. GODSEY (A'30) (310 Alden Ave., New Haven, Conn.)

Personal

Kaiden-Keystone Studios
H. S. WARREN

R. N. CONWELL

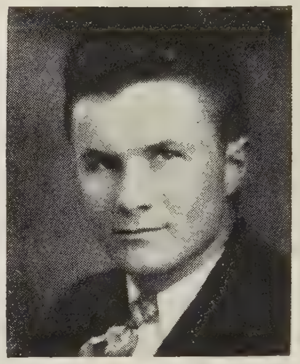
Kaiden-Keystone Studios
A. E. SILVER

H. S. WARREN (A'03, F'13) protection development engineer, the American Telephone and Telegraph Company, New York, N. Y., shares the 1931 A.I.E.E. national prize for best paper in engineering practise, which was awarded the symposium on coordination of power and telephone plant. Mr. Warren's contribution to this symposium was the paper "Status of Joint Development and Research on Low-Frequency Induction" in joint authorship with R. N. CONWELL (A'15, F'31). A native of Oldtown, Maine, he went west in 1894 and entered upon an electrical engineering course at Leland Stanford, Jr. University, Calif. From this he was graduated in 1898 with his A.B. degree. His first practical electrical work was done while serving as electrician for the U. S. Fur Seal Commission. Immediately after graduation from the university he entered the employ of the Standard Electric Company of California, in San Francisco, and undertook the study of electrical constants and the transpositions for its projected 50,000-volt transmission line from Amador County to San Francisco. He next took a position with the California State Board of Harbor Commissioners and later in 1898 he engaged with the Nevada County Electric Power Company, Nevada City, Calif. But Mr. Warren's real life work has been in the field of communication. September 1899 he joined the American Bell Telephone Company, and since then he has devoted his entire effort to progress and improvement in this field. For many years he was in responsible charge of the design and development of some of the apparatus most vital to telephone systems. He designed and reduced to practical form, the loading coil which carried out the inventions of Doctor Pupin, designing cables and studying the loading of cables in connection with these inventions. He designed coil for, and reduced to practise also, the phantom circuit, an accomplishment not only highly interesting scientifically but one which made possible the operation of many thousands of miles of circuits. He is a member of Western Universities and the Engineers' Club, and past-president of the Telephone Society of New England.

R. N. CONWELL (A'15, F'31) transmission and substation engineer for the Public Service Electric and Gas Company, Newark, N. J., shares with his coauthor H. S. WARREN (A'03, F'13) in the 1931 A.I.E.E. national prize for best paper in engineering practise, which was awarded the symposium on coordination of power and telephone plant. The title of their paper was "Status of Joint Development and Research on Low-Frequency Induction." Mr. Conwell, a native of Anderson, Ind., is a graduate of Purdue University and of the George Washington University, Washington, D. C. As engineer in charge of acceptance tests of the sewage pumping station for the sewer department of the District of Columbia, his first professional work was done. In 1911 he was employed as cadet engineer by the Public Service Electric Company of Newark, N. J., later as laboratory assistant, and chief of the materials division of laboratory testing.

In transition to his present work he became assistant engineer of the engineering department in charge of station and substation design, system protection, and general engineering work. In 1922 he was made transmission engineer of the distribution department. As such he has organized and placed in operation a complete system of load forecasting and planning for budget purposes. To secure a more efficient distribution of power and a better continuity of service, Mr. Conwell completely redesigned and reconstructed the transmission system of his company. In 1925 he was appointed to his present position. His contributions to technical literature and discussion have been abundant and his committee activities with the A.I.E.E., National Electric Light Association, American Standards Association, American Committee on Inductive Coordination, National Fire Protection Association, and the Association of Edison Illuminating Companies, all too numerous to list. He also has to his credit over 2 dozen patents granted and pending. He is the inventor of the present type of inverse current relay for transmission and line work as made by the Westinghouse Electric and Manufacturing Company, and has done outstanding work in the inductive interference field.

A. E. SILVER (A'07, F'26) consulting electrical engineer for the Electric Bond and Share Company, New York, N. Y., was among those to receive the 1931 A.I.E.E. national prize for best paper in engineering practise, awarded the symposium on coordination of power and telephone plant, the paper "Trends in Telephone and Power Practise as Affecting Coordination" prepared by him and W. H. HARRISON (A'20, F'31) being an integral part of the prize symposium. Mr. Silver who is a native of Dexter, Maine, received his early education there. Entering upon an electrical engineering course at the University of Maine, he was graduated with the class of 1902, and then entered the test department of the General Electric Company at Schenectady, N. Y. In 1904 he accepted a position with the Raleigh



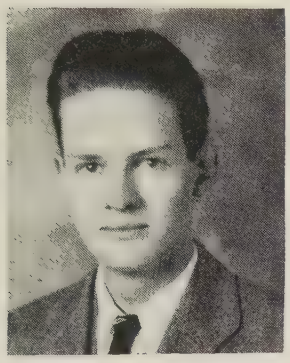
C. A. CHURCH

Electric Company, Raleigh, N. C., remaining over a period of years in charge of its meter department, and also working on switchboard construction, generating stations, and overhead lines. With the coming of a new régime, in 1906, the departmental work was divided into steam and electric activities, Mr. Silver remaining in charge of the electrical work. Later in that same year he accepted the position of chief engineer and electrical superintendent of the Carolina Power and Light Company, Raleigh, N. C., this company representing the consolidation of several central stations and street railway properties of that section, as well as transmission and hydroelectric plants of the vicinity. In 1910 he became electrical engineer of the Electric Bond and Share Company and removed to New York City. The work with this company included responsible charge of design of generating stations, substations, transmission and distribution systems. Mr. Silver has served on both the power generation committee and the power transmission and distribution committee of the Institute, and since 1915 has been actively connected with committee work of the National Electric Light Association, now serving as counselor of the overhead systems committee, and of the foreign systems coordination committee; a member of the special engineering committee on lighting and marking airways and of the N.E.L.A.–Bell Telephone system joint development and research committee; and vice-chairman of the engineering national section. He has served also on committees of other well-known and national organizations including the Bureau of Standards. He is a Fellow of the American

W. H. HARRISON

J. C. MARTIN

G. L. LILLIE



C. E. HOUSTON

Association for the Advancement of Science, and a member of the Montclair Society of Engineers, of Montclair, N. J.

W. H. Harrison (A'20, F'31) who with A. E. Silver (A'07, F'26) his coauthor of the paper "Trends in Telephone and Power Practise as Affecting Coordination" shares in the 1931 A.I.E.E. national prize for best paper in engineering practise, awarded the symposium on coordination of power and telephone plant, is plant engineer of the American Telephone and Telegraph Company, New York, N. Y. Mr. Harrison who was born in Brooklyn, N. Y., was graduated from the electrical engineering course of Pratt Institute, Brooklyn, and in 1909 joined the New York Telephone Company in New York City, as repairman. His work until 1915 included apparatus inspection, assembling, and wiring; then he accepted a position on telephone circuit design work with the Western Electric Company in its engineering department. Three years later he joined the engineering Staff of the American Telephone and Telegraph Company for general plant maintenance engineering work; and in 1924 was made equipment and building engineer with general supervision of the engineering and design (including layout) of subscribers' station and the central office plant of the Bell system. He became plant engineer in 1929, this appointment giving him charge of the engineering, design, and layout of all parts of the Bell system plant including system relations with other wire-using utilities. Among other achievements, Mr. Harrison is said to have brought order out of chaos in connection with a large and important merger of several telephone systems in California, where he accomplished the standardizing and improvement of maintenance features of telephone equipment and contributed greatly to the application to and adoption of mechanical systems for telephone plants in the United States.

J. C. Martin (A'12) electrical engineer of Middle West Utilities Company, Chicago, Ill., who with H. L. Huber (M'23) prepared the paper "Status of Cooperative Work on Joint Use of Poles" which was a part of the symposium on coordination of power and telephone plant shares in the 1931 A.I.E.E. national prize for best paper in engineering practise awarded to this symposium. Mr. Martin was born at Solon, Iowa, and obtained his early technical education by home study with the International Correspondence School. In 1903 he engaged with the Cedar Rapids and Iowa City Railway and Light Company, doing office work for 2 years after which he was advanced to construction, line, and power plant work. In 1911 he joined the engineering department of the Pacific Power and Light Company, first as distribution engineer, later being made chief engineer in charge of all design and construction work. During this period he was located at Portland, Ore. In 1917 the Pennsylvania Power and Light Company of Allentown, Pa., chose him as its chief engineer. Here he remained until 1920, when he became western editor of *Electrical World*, located in Chciago. His history with the operating department of the Middle West Utilities Company started in 1923. By the Pacific Power and Light Company he was considered a specialist on electrical distributing systems.

C. E. Houston (A'32) assistant, department of physics, Texas Technological College, Lubbock, Texas, has received the South West District prize for Branch paper presented during the year 1931, in connection with the presentation of his paper "Accumulation of High-Potential Static Charges on Transmission Lines During Sand Storms." Mr. Houston was born at Salado, Texas, and earned his B.S in E.E. from Texas Technological College in 1931. From 1927 to 1928 he was chemistry assistant at the college, and from 1930 to 1931, physics assistant. In 1930 while an undergraduate student he undertook research work on static charges on transmission lines due to sand storms and it was during this interval that data contained in his prize winning paper were acquired. He has continued his research work and his thesis in connection with graduate work in physics also has this as a subject. Upon this he will receive his M.A. in August 1932.

G. L. Lillie (A'21) who has received both of the 1931 A.I.E.E. Canada District prizes for best paper and initial paper for his paper "Factors in Design of 115–230-Volt Distribution in a Modern Residential District," is assistant engineer of distribution for the Toronto Hydro-Electric System, Toronto, Canada. He was born at Colbourne, Ontario, Can., and for a while after his graduation from the University of Toronto in 1911, was employed by the Toronto Hydro-Electric System. In October of 1912 he left and for a few months was in the shops of the Westinghouse Company, at Hamilton, Can. He then returned to the University of Toronto for a postgraduate course, and in 1913 was graduated with his degree in electrical engineering. He at once returned to the employ of the Toronto Hydro-Electric System, but in September 1917 left to join the Canadian navy. He received his discharge in January 1919 and again returned to his company, where he has continued to serve to date.

C. A. Church (Enrolled Student) University of Colorado, Boulder, Colo., has been selected to receive jointly with N. R. Damon, coauthor, the 1931 A.I.E.E. North Central District prize for Branch paper. This choice was made based upon the paper entitled "New Ideas for High Voltage Circuit Breakers." Mr. Church was born at Goodell, Iowa. His high school education was obtained at Longmont, Colo., where he was graduated with honors in 1927. As a Fellow at the University of Colorado, he received his B.S. in E.E. there in 1931. At present he is engaged in graduate study and research in electrical engineering at the University of Colorado. This work is supplementary to that by which he earned his M.S. degree June 1932. His fraternal affiliations are Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

W. B. Kouwenhoven (A'06, M'22) vice-president of the Institute for the Middle Eastern District, and professor of electrical engineering and assistant dean of The Johns Hopkins University, Baltimore, Md., has been accorded special honors by those in charge of the International Electrical Congress being held in Paris this month (July 4–12, 1932). Doctor Kouwenhoven in collaboration with Dr. O. R. Langworthy prepared a paper "Injuries Produced by Contact With Electric Circuits" for presentation in Paris, embracing

the findings of their original and extensive research work at The Johns Hopkins University. According to a report recently received, "Because of the interesting work of Messrs. Kouwenhoven and Langworthy [the committee] listed their contribution as a report and not as a paper." The significance of this recognition is that the paper will appear as an independent, individual contribution and not as a part of any general report; also the authors are exempt from the payment of membership fees, and in addition will be awarded the sum of 2,000 francs as part payment of expenses for attendance at the congress. (Editor's Note: The important findings of Doctor Kouwenhoven's work have been covered from time to time in his contributions to the pages of Electrical Engineering; others are scheduled for the future.)

L. A. Magraw (A'07, M'13) president and general manager of the South Carolina Power Company of Charleston, S. C., at a recent Southeastern Division conference of the National Electrical Light Association was chosen to serve as its president; and J. M. Barry (A'11) vice-president in charge of operation for the Alabama Power Company, Birmingham, Ala., became the second vice-president of this same division of the N.E.L.A.

R. A. Millikan (M'22) director of the Norman Bridge Laboratory and chairman of the executive council of the California Institute of Technology, Pasadena, Calif., recently was reelected president of the board of directors of the National Advisory Council on Radio in Education. M. I. Pupin (A'90, F'15, HM'28 and past-president) also received reelection to the vice-presidency of the Council.

S. A. Knight (A'31) who last year was assistant engineer for the Irak Petroleum Company, Ltd., of Manchester, England, with headquarters in Tuz Khurmatu, Province of Irak, recently returned to Great Britain to become assistant technical engineer for the Central England Board, in its North West area. The home office of the board is at Manchester, England.

J. E. E. Royer (A'15) general manager of The Washington Water Power Company, Spokane, Wash., has been made vice-president as well. Mr. Royer who came to The Washington Water Power Company in 1907, became assistant superintendent of the light and power department in 1919, assistant general manager in 1924, and general manager 2 years ago.

S. P. Grace (A'03, F'21) assistant vice-president of the Bell Telephone Laboratories, Inc., and well known for his popular lectures on various advances in the science of communication, recently received the degree of Doctor of Engineering from the University of Michigan, and the honorary degree of Doctor of Laws from Notre Dame University.

George Fiske (A'11) who has been serving the General Electric Company at Kansas City, Mo., as its assistant manager, now has been made manager of the company's office there, it was recently announced. Mr. Fiske joined the company in 1904 as a test man, and barring military service 1917–19, has been continuously with it to date.

G. W. Elmen (M'21, F'27) telephone engineer for the Bell Telephone Laboratories, Inc., and inventor of the magnetic alloys, permalloy and perminvar, has received the honorary degree of Doctor of Engineering from the University of Nebraska, his alma mater. At the laboratories, Mr. Elmen is in charge of research in magnetic materials.

E. R. Hedrick (M'25) professor of mathematics and chairman of the department of mathematics at the University of California, Los Angeles, has been awarded the title of "Officier d'Academie" by the French government, "for services rendered to the cause of culture and science."

F. L. Kradel (A'27) who for some time was sales engineer for The Champion Switch Company of Kenova, W. Va., and subsequently removed to Millvale, Pa., recently became representative for the Royal Electric Manufacturing Company, Chicago, Ill., in its southern Pennsylvania and West Virginia territory.

J. W. McCartin (A'20) previously of the engineering department of E. L. Phillips and Company, New York, N. Y., now is chief operator for the Nassau division of the Long Island Lighting Company, Glenwood Landing, N. Y. His office with the Phillips company was that of power plant and substation designer.

A. H. Gfrorer (A'14) for the past 13 years chief engineer of the Automatic Transportation Company of Chicago, Ill., and in addition to these duties, for the past 3 years holding like office with the Barrett Cravens Company, Chicago, Ill., resigned from both of these organizations as of June 30, 1932.

K. W. John (A'29) has resigned his position as chief electrician of the Graham Paige Motors Corporation, Detroit, Mich., and on June 1, 1932 became affiliated with the United States Rubber Company, Detroit, Mich., as technical engineer of its plant in that city.

N. Miridjanian (A'31) who for the past year or so has been associated with the Columbia Graphophone Company, Istanbul, Turkey, recently established the "Gans" Electroplating Works, which he announces is the first modern electroplating shop in Istanbul.

Dick Pyper (A'29) who in the past has been associated with the Southern California Edison Power House No. 3 at Big Creek, Calif., recently became hydroelectric power house operator of the Turlock Irrigation District, at Turlock, Calif.

W. R. Thorson (A'26) who previously was superintendent of electrical distribution for the Consumers Power Company at Hudson, Mich., recently was made superintendent of public works for the City of Waverly, Iowa.

P. W. Buchhart (A'32) who in 1931 served the Pennsylvania Railroad Company, Philadelphia, Pa., as draftsman, is now engineer and director of the International Patent Commercialization Company, Inc., New York, N. Y.

W. T. Powell (A'14) previously patent engineer for the Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., now is serving the General Railway Signal Company, that city, as its patent attorney.

H. K. V. Tompkins (M'31) who last year was associated with the Gulf Produce Company, Houston, Texas, now is assistant to the president of George F. Getty, Inc., and Pacific Western Oil Company, Los Angeles, Calif.

R. B. H. Rockwell (A'29) previously in the operating engineering department of the Georgia Power Company at Atlanta, Ga., now has been transferred to that company's office at Macon, Ga., as lighting engineer.

J. P. Grable (A'22) who heretofore has been identified with the General Cable Corporation, Fort Wayne, Ind., now is coil engineer of the American Enameled Magnet Wire Company at Port Huron, Mich.

Ernest Kauer (A'25) who in the past has been president of the CeCo Manufacturing Company, Providence, R. I., recently changed to become president of the Molding Corporation of America, of that city.

W. S. Lee (A'04, F'13 and past-president) chief engineer of the Duke Power Company, Charlotte, N. C., recently received the degree of Doctor Laws from The Citadel Military College of South Carolina.

Thomas Paden (A'28) formerly superintendent of distribution of the Ohio Edison Company, Youngstown, Ohio, now is electric superintendent of the Pennsylvania Power Company, New Castle, Pa.

C. N. Johnson (A'17, M'26) engineering manager of the Westinghouse Electric and Manufacturing Company, Philadelphia, Pa., now has joined the company's forces at 150 Broadway, New York, N. Y.

W. C. Sealey (A'25) who recently became identified with the Allis-Chalmers Manufacturing Company's office at Milwaukee, Wis., has been transferred to its works at Pittsburgh, Pa.

E. F. Mekelburg (A'21, M'30) who has been serving Cutler-Hammer, Inc., Milwaukee, Wis., as supervisory engineer, now

is identified with the Industrial Controller Company of Milwaukee.

F. W. Pembleton (A'20) formerly winding supervisor of the General Motors Radio Corporation, Dayton, Ohio, now is chief engineer of the Volume Control Service, Fort Wayne, Ind.

L. R. Milburn (A'20, M'31) who was assistant electrical engineer of the Great Lakes Steel Corporation, Detroit, Mich., now is electrical engineer for that same company at Ecorse, Mich.

R. R. Black (A'30) once the General Electric Company's electrical engineer at Fort Wayne, Ind., now is engineer of the Polymet Manufacturing Corporation, New York, N. Y.

C. D. Raymond (A'27) who has been an electrical engineer for the General Electric Company at Newark, N. J., recently joined the Ellenville Electric Company, at Ellenville, N. Y.

C. H. Roth (A'11) who has been president of Roth Brothers and Company, Chicago, Ill., now is president of the Light Sensitive Apparatus Corporation, at Niles Center, Ill.

Herbert Hoover (HM'29) President of the United States, recently received from Gettysburg College, Gettysburg, Pa., *in absentia* the degree of Doctor of Science.

André Mestraud (M'24) of Lanobre, Cantal, France, has recently been made directeur de l'Energie Electrique du Littoral Meditarraneen, at Marseille, France.

Obituary

Walter Throop Kendall Brown (A'07, M'13) chief of the engineering staff of the Winchester Repeating Arms Company, New Haven, Conn., died at his home at Short Beach, Conn., June 12, 1932. He was born at Paterson, N. J., February 26, 1874, and after obtaining his elementary education in the New York State public schools, entered upon a scientific course at the Williston Seminary at East Hampton, Mass. Thereafter he attended the Cincinnati Art Academy for design and woodcarving; then, returning to the New England section, joined the night school of the Brooks Locomotive Works, well known in the nautical world. Pursuing this bent, he completed a course in ocean navigation with the International Correspondence School, also taking up the subjects of electric railways, lighting and interior wiring, electric transmission, and steam boilers. He then made an exhaustive 3-year study of the deviation of the compass on iron ships. Mr. Brown was at one time chief petty officer in the United States Navy, spending $1^1/_2$ years in the pay department and $2^1/_2$ years on construction repair equipment and electrical equipment. He has also served as quartermaster and officer of the U.S. and British Merchant Marine. From 1904 to 1912 he was with the Stanley Electric Manufacturing Company and the General Electric Company's Pittsfield Works, as erecting engineer for central stations, assistant works manager for fire protection, and electric superintendent of maintenance and equipment. In 1912 he became assistant general manager and supervising engineer of the Star Electric Company, subsidiary of the General Electric Company, and as such had charge of checking fire alarms and police telephones; organized and put in a complete manufacturing system, and supervised engineering manufacture and construction. In 1915 he joined his last company, the Winchester Repeating Arms Company of New Haven, as equipment engineer and manufacturing engineer. He was particularly successful in organization work and the training of young engineers.

Besides his Institute connection, Mr. Brown held membership in the Society of Military Engineers, the Spanish War Veterans, the Massachusetts Society, Sons of the American Revolution, and the Crescent Lodge of Masons, Pittsfield, Mass.

John Oliver Montignani (A'06, M'13) who while in New York, N. Y., made the Fraternity Club his headquarters, died of pneumonia at the home of his brother, at Woburn Green Bucks, England, May 12, 1932. Mr. Montignani was born at Edinburgh, Scotland, April 7, 1880. He entered the George Watsons College at Edinburgh in 1887 and in 1895 was graduated from the commercial division. The period 1895–9 was spent in study on electrical subjects, and in conjunction with this academic work he was receiving practical training in the engineering field under a 5 years' indenture with the firm of James Milne and Son, Limited, at Milton House Works, Edinburgh. This course was completed in 1901 and Mr. Montignani undertook a special study of electric railway engineering, coming to the United States in the fall of 1902, to follow up this line of endeavor. Upon arrival here he went to work in the experimental department of the Consolidated Car Heating Company of Albany, N. Y., and until June 1903 was employed in its car lighting system. He then left to enter the employ of the Rochester Railway Company, at Rochester, N. Y., where he was employed as assistant engineer. Four years were spent in the design, supervision, and installation of transmission lines, general overhead construction, and substation equipment; for 4 years more he was engineer of electrical distribution; another 4 years were spent as assistant engineer upon New York State railways. Subsequently he was made division superintendent of the Rochester Railway and Light Company at Rochester, N. Y., and in 1926 became assistant electrical engineer of the Westchester Lighting Company at Yonkers, N. Y., a position which he continued to fill over a period of several years. In 1930 he was made engineer of electrical transmission for Stevens and Wood, Inc., New York, N. Y.

Harold Seaburg (A'24, M'29) chief electrical engineer of the United Fruit Company, Banes Division, Oriente, Cuba, died March 13, 1932, after a week's illness with pneumonia. Mr. Seaburg was a native of Tranas, Sweden (Nov. 27, 1897), and completed both grade school and technical college in an electrical engineering course, at Orebro, Sweden. In 1918 he became a draftsman of the Swedish General Electric Company, at Vesteras, Sweden, and 2 years later took up the duties of assistant electrical engineer in addition to his work as a draftsman with the Star Electric Motor Company at Newark, N. J. In 1922 as draftsman he joined the power division of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and the following year became a draftsman in the engineering department of the New York Edison Company, New York, N. Y. As assistant electrical engineer of the Havana Central Railroad Company, Cuba, he detailed the layout, installation, and operation of the main switchboard equipment in Melones power plant of this company, and in its 3 railway and lighting substations. He also was largely responsible for the installation of the central power plant in the city of Havana, Cuba. As chief electrical engineer of the United Fruit Company, Banes, Oriente, Cuba, he was in charge of all electrical equipment in the electrified sugar central which has a normal annual output of about 700,000 bags.

George Crisson (A'09, M'30) who has been with the American Telephone and Telegraph Company, New York, N. Y., since 1910, died at the Presbyterian Hospital in Newark, N. J., May 22, 1932. Mr. Crisson was born at Astoria, N. Y., October 2, 1885. His M.E. degree was conferred upon him by Stevens Institute of Technology, Hoboken, N. J., to which he returned as an instructor in electrical engineering in 1906. In this capacity he continued until 1910, the year of his joining the American Telephone and Telegraph Company for the design and testing of fittings and structures used in outside plant construction. In 1914 he changed over to development work on transmission problems, principally in the application of telephone repeaters to the improvement of long distance transmission, but including related matters, such as amplifiers for public speaking systems, voice-operated apparatus for the suppression of echoes and singing on long distance wire circuits, the transatlantic radiotelephone circuits, and proposed transatlantic cable. Several patents in this field were the results of work, and were incorporated in the company's communication system and specifically in the dial telephone.

William Franklin Yeager (A'27) engineer of the United Engineers and Constructors, Inc., Philadelphia, Pa., died February 13, 1932. Philadelphia was his place of birth, September 18, 1879; there also he received the major portion of his grade schooling, going later to the Williamson Free School of Mechanical Trades, Williamson, Pa., from which he was graduated as an elec-

trical machinist in 1899; Mr. Yeager's experience in the commercial world was broadly diversified, including much of design, construction, and machine work in other than electrical fields. For H. S. Farquhar, Philadelphia engineer, he did detailed structural and mechanical calculation, and electrical and mechanical investigation of plant equipment at the Jefferson Hospital, Philadelphia, and investigation and report on electrical machinery, testing of generators, indicator tests on engines, and coal and water rating tests on boilers at the Rittenhouse Club, Philadelphia. For Day and Zimmermann, Inc., later the Day and Zimmermann Engineering and Construction Company, he functioned as engineer and chief draftsman, chief structural engineer, and finally consulting engineer, spending 7 years in the company's employ. During the period 1918–1920 as design engineer for Day and Zimmermann his work was the supervision of engineers, under the direction of the Construction Division of the U.S. Army, on the Philadelphia Quartermaster Terminal and the Motor Transport headquarters. The supervision of design for a power plant at McAllister, Okla., also was Mr. Yeager's work, as was the investigation and report on terminal warehousing and motor and rail facilities on Long Island, N. Y. Most of his latter work was investigation and report for his company on development and possible betterment of many large activities.

Harold Bailey Brigham (A'31) engineer of the Byllesby Engineering and Management Corporation, with the Oklahoma Gas and Electric Company, Oklahoma City, Okla., died April 10, 1932 in that city. He was born at Belle Plain, Kans., July 23, 1899, and won his degree of B.S. in E.E. at the University of Oklahoma in 1923. After graduation he joined the distribution engineering department of the Oklahoma Gas and Electric Company, his affiliation with this company representing rapid progress through its various departments; extension engineer in the contracts department; division engineer; back to the distribution engineering department; in the office of the general superintendent; assistant distribution engineer in 1928. That same year he became a member of the Oklahoma City auxiliary force of engineering of the Byllesby Engineering and Management Corporation, the organization with which he was identified at the time of his death.

Thomas McLean (A'11) who for many years served the Los Angeles Gas and Electric Corporation, Los Angeles, Calif., in varying capacities of operator and as foreman of substation operators, died Friday, May 13, 1932. A native of Long Island, N. Y., Mr. McLean in 1895 at the age of 17 engaged with the Brooklyn Edison Company, Brooklyn, N. Y., starting as a trimmer and advancing to generating station operator, the position which he held until he resigned in 1910. Thence he went directly to Los Angeles and joined the Los Angeles Gas and Electric Corporation. Here he was a meter tester, a work which he continued over a period of years. In 1923 he assumed the title of operator, and a year or so later was made foreman of substation operation.

Henry Worrell Beers (A'25) of the H. W. Beers Company, Mexico, D. F., Mex., died there the 10th of April 1932. Although for years a resident of Mexico and the head of an established electrical supply business there, Mr. Beers was a native of the United States, having been born in Columbus, Miss., December 31, 1876. Before founding his own business, he worked for the Mexican Light and Power Company, Mexico City, over a long period of years.

Jin Tachihara (A'98) manager of the Mitsubishi Electric Company, Tokyo, Japan, and prominent in the engineering profession of that country, died December 16, 1931. At the time of his becoming a member of the A.I.E.E., Mr. Tachihara was affiliated with the General Electric Company of Schenectady, N. Y.

Local Meetings

Oklahoma City Section Meets With Branches

The annual joint meeting of the Oklahoma City Section and the student Branches at the Oklahoma A. & M. College and the Univ. of Oklahoma, was held at the latter school on May 16, 1932. Students of the 2 schools presented the following technical papers:

Morning

Measurement of Distortion, by J. L. Lisk, Univ. of Okla.

Manufacture and Use of Tungsten Carbide Diamond Substitutes: Electrical and Other Considerations, by G. L. Keyser, Okla. A. & M. Col.

Calculating Tables for Distributed Loads on Transmission and Distribution Circuits, by F. H. Cullison, Univ. of Okla.

Economics of Rural Line Distribution, by B. E. Lowe, Okla. A. & M. Col.

A luncheon was held at the Student Union Building, followed by a short tour of inspection through the various engineering buildings.

Afternoon

Voltage Regulating Transformers and Their Application, by C. A. Ludwick, Univ. of Okla.

Jet Wave Rectifiers, by L. S. Cox, Okla. A. & M. Col.

Class B Amplifiers, by J. L. Callahan, Univ. of Okla.

Control of Gyroscope Stabilizers for Prevention of Rolling of Heavy Sea-Going Vessels, by P. O. Bobo, Okla. A. & M. Col.

Prizes for the above papers were awarded as follows:

First prize ($15) Bernard E. Lowe, Oklahoma A. & M. Col.

Second prize ($10) Charles A. Ludwick, Univ. of Okla.

Third prize ($5) Powell O. Bobo, Okla. A. & M. Col.

After the student meeting, the Oklahoma City Section held a short business meeting and the new officers were announced as indicated: E. B. Jennings, chmn.; R. F. Danner, vice-chmn.; C. E. Bathe, secy.-treas. The attendance was 80.

Past Section Meetings

Akron

Banquet. Election of officers: A. P. Regal, chmn.; W. H. Tucker, secy. Human Engineering, by Dean F. E. Ayers, Univ. of Akron. May 10. Att. 47.

Baltimore

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E. Election of officers: J. Wells, chmn.; L. G. Smith, vice-chmn.; J. L. D. Speer, secy.-treas. May 27. Att. 37.

Cleveland

Mystery and Musical Telepathy, by Mr. and Mrs. DeJen. Election of officers: J. M. Smith, chmn.; S. B. Taylor, secy.-treas. May 26. Att. 110.

Connecticut

Some Practical Problems in the Operation of High Tension Network Systems, by C. W. Mayott, Connecticut Valley Pwr. Exchange. April 14. Att. 60.

Dallas

Finances, by J. E. Owens, Republic Natl. Bank and Trust Co. Election of officers: H. K. Handley, chmn.; W. B. Folline, secy. May 16. Att. 58.

Denver

Election of officers: W. D. Hardaway, chmn.; A. W. Ainsworth, vice-chmn.; N. R. Love, secy.-treas. May 5. Att. 14.

Moving pictures presented under the auspices of the Colorado Museum of Natural History. Dinner. June 1. Att. 38.

Detroit-Ann Arbor

Adventures in Science, by Oliver Ajer, Genl. Elec. Co. Demonstrations. May 17. Att. 325.

Erie

Lighter Than Air Craft, by V. R. Jacobs, Goodyear Tire & Rubber Co. May 17. Att. 175.

Iowa

Election of officers: L. F. Wood, chmn.; B. S. Willis, secy.-treas. May 24. Att. 11.

Kansas City

Banquet. The Requirements for Business Recovery, by Prof. J. H. Taggart, Univ. of Kansas. Election of officers: G. O. Brown, chmn.; E. W. Harvey, secy.-treas. May 26. Att. 53.

Lehigh Valley

Aeroplane and Ship to Shore Communication, by L. Espenschied, American Tel. & Tel. Co. Feb. 12. Att. 104.

Recent Advances in Engineering as Applied to Industry and the Home, by C. K. Lee, Westinghouse Elec. & Mfg. Co. Illus. April 22. Att. 117.

High Voltage Cables—Their Manufacture and Application, by D. M. Simmons, Genl. Cable Corp. Election of officers: J. G. Charest, chmn.; W. A. Skinner, secy. May 13. Att. 90.

Los Angeles

Boat trip around the Los Angeles harbor and dinner. May 14. Att. 60.

Louisville

New Dial Telephone Equipment, by H. C. Walker, Southern Bell Tel. & Tel. Co. Demonstrations. Inspection of the new telephone building and equipment. May 13. Att. 87.

Lynn

Inspection trip of the East Boston Airport of the Curtis-Wright Flying Service. April 23. Att. 300.

Madison

Governors and the Governing of Prime Movers, by Albert Kalin, Woodward Governor Co. Inspection trip through the plant of the Woodward Governor Co. May 21. Att. 57.

Mexico

Comparison Between Group Drive and Individual Drive in Shops, by L. Castro, Jr., Natl. Railways of Mexico. May 19. Att. 30.

Milwaukee

Modern Manchuria, by Prof. H. E. Babbitt, Univ. of Ill. Joint meeting with Engrs. Soc. of Milwaukee. April 20. Att. 300.

Educational Future of the College of Engineering, U. of Wis. by Dean F. E. Turneaure; Reminiscences of an Engineer, by Prof. D. W. Mead; Plan Development for the College of Engineering, by Arthur Peabody; The Need of a Two Year Course in Engineering, by Arthur Simon. F. H. Dorner presented a tablet with pictures donated to the University on the occasion of the dedication of the new mechanical engineering building. Dinner. May 27. Att. 250.

Recent Applications of the Vacuum Tube in Industry, by R. E. Welton, Genl. Elec. Co. Election of officers: W. F. Lent, chmn.; C. D. Brown, secy.-treas. June 1. Att. 60.

Montana

Commutation in Generators and Motors Used in Mine Hoists, by A. W. Boyer; Electrical Properties of Hardened Copper, by H. Lambdin and A. J. Hill, students, Montana State Col. Election of officers: J. A. Thaler, chmn.; H. Dale Cline, secy. June 4. Att. 23.

Nebraska

The Engineer in Society and Industry, by T. W. McCullough, Omaha Bee News. Joint meeting with Univ. of Nebraska Branch. May 11. Att. 106.

Short talks by Professors Caldwell and Brookman, Univ. of So. Dakota, P. H. Patton, vice-pres. A.I.E.E., and John Gibb, pres. Omaha Engrs.' Club. Joint meeting with Univ. of So. Dakota Branch. May 17. Att. 25.

New York

Lighting Requirements for Publishing Operation, by E. Whitehorne, McGraw-Hill Co., Raymond Hood, and Fouilhoux, and D. Wood, Lockwood Greene Engrs., Inc. May 12. Att. 150.

Niagara Frontier

Ladies' night. May 20. Att. 75.

Philadelphia

Transoceanic Telephony, by H. S. Osborne, Am. Tel. & Tel. Co. Election of officers: Prof. L. Fussell, chmn.; J. L. MacBurney, secy.; E. C. Drew, treas. May 9. Att. 150.

St. Louis

General descriptions of the transmission lines from the Bagnell Station were given by L. T. Byers, Stanley Stokes, and H. E. Gove of the Union Elec. Lt. & Pwr. Co., and F. G. Dana and G. W. Couch of Stone & Webster Engg. Corp. May 18. Att. 98.

Seattle

The Use of Electricity in the Electrochemical Industry, by L. Supovi, Hooker Electrochemical Co. Election of officers: A. F. Darland, chmn.; G. L. Hoard, vice-chmn.; K. L. Howe, secy.-treas. May 17. Att. 66.

Sharon

The Use of Aluminum in the U.S.S. Akron, by G. O. Hoglund, Aluminum Co. of America. Moving pictures. May 31. Att. 95.

Spokane

Steam Power Plant Developments Including Mercury Boilers and Turbines, by W. F. Hynes, Genl. Elec. Co. April 22. Att. 38.

Syracuse

Steam Electric Power Plants, by I. E. Moultrop, Edison Elec. Ill. Co. of Boston, vice-pres. A.I.E.E. March 7. Att. 38.

International Engineering Congress, by Dr. C. E. Skinner, Westinghouse Elec. & Mfg. Co., pres. A.I.E.E. Joint meeting with Technology Club of Syracuse. May 9. Att. 225.

Past Branch Meetings

University of Akron

The Firestone Power Plant, by W. J. Boyd, student. F. J. Marcinkoski, student, gave a demonstration of resuscitation. Election of officers: F. J. Marcinkoski, chmn.; R. A. Ries, secy. May 13. Att. 10.

University of Arizona

The Deion Grid Circuit Breaker, by B. Watkins, student. April 29. Att. 8.

Discussion. April 22. Att. 8.

Film—"Dynamic America." May 6. Att. 27.

Some Thoughts on Technical Education and The Vernier Slot Effect, by Prof. J. C. Clark, counselor. May 13. Att. 8.

Research on Dielectric Losses in Insulating Materials, by F. A. Decker. May 20. Att. 10.

The Colorado River and the Boulder Canyon Dam, by O. H. Polk. Election of officers: Bruce Watkins, chmn.; Jack Jones, vice-chmn.; H. Stewart, secy.-treas. May 26. Att. 8.

University of Arkansas

Plotting Magnetic Fields, by H. G. Thomasson, student; The Tesla Coil, by C. L. Mowery, student; Rural Electrification, by H. H. Lewis, student; Rates, by F. L. McDonald, student. May 2. Att. 25.

Carrier Currents, by W. F. Stewart; Long Distance Communication, by L. C. Wasson; Armature Reaction, by W. C. Whitfield; Hydro-electric Dams, by E. E. Cato; Transoceanic Cables, by W. D. Thornberry; Cathode Ray Oscillograph, by R. E. Cope, all students. May 16. Att. 24

Brooklyn Polytechnic Institute

Regenerative Braking on Direct-Current Railways, by Charles Pedersen, student; Use of Thyrite in the Arms of a Wheatstone Bridge, by F. Rae, student; A Brief History of Photo-electricity, by Frank Maloney, student. Election of officers: I. Andreasen, chmn.; H. Hoffman, vice-pres.; Robert Hampshire, secy.; Charles Pedersen, treas. May 18. Att. 39.

Bucknell University

Film—"Dynamic America." Lecture on the photoelectric cell. May 17. Att. 125.

California Institute of Technology

Transpacific Radio Communication, by F. H. Kroger, R. C. A. Motion pictures. May 24. Att. 35.

University of California

Election of officers: Wm. D. Hudgins, chmn.; V. Welge, vice-chmn.; L. R. Rockholt, secy.; H. Lorenzen, treas. April 27. Att. 11.

University of Cincinnati

Joint meeting with the Cincinnati Section with papers by students as follows: A Laboratory Arc Furnace, by E. J. Emmerling; Measurement of Modulation, by J. Epstein; Constant Radio Frequency, by A. C. Herweh; Measurement of Radiation, by C. L. Ramsey; An Electric Organ, by W. E. Kock. May 12. Att. 80.

Clemson Agricultural College

Inspection trip to the hydroelectric plants of the Georgia Pwr. Co. April 18. Att. 85.

Election of officers: C. P. Walker, chmn.; T. M. Watson, vice-chmn.; W. F. Tribble, secy.-treas. May 12. Att. 20.

University of Colorado

A New Method for Measuring Angular Displacements in Synchronous Machines, by L. L. Mundell and W. C. Spear, students. May 18. Att. 35.

Cornell University

Teletypewriter Systems, by B. K. Boyce, N. Y. Tel. Co. April 22.

University of Denver

Election of officers: Paul Barth, chmn.; F. A. Dow, vice-chmn.; Carl Hedberg, secy.-treas. May 11. Att. 12.

University of Detroit

Banquet. History of Electric Lighting in Detroit, by J. W. Bishop, Ford Motor Co. Election of officers: J. A. Schenk, chmn.; A. Manning, vice-chmn.; Ralph Martin, secy.; Frank Belch, treas. June 1. Att. 33.

Drexel Institute

The Development of Long and Short Wave Transmitters, by C. E. Keener, student. May 4. Att. 21.

Election of officers: F. P. States, chmn.; R. W. King, vice-chmn.; F. A. Hipple, secy.; F. E. Seaman, treas. May 18. Att. 15.

Duke University

Banquet. Election of officers: Tom Garrett, chmn.; John Womack, vice-chmn.; H. W. Atkinson, secy. May 12. Att. 16.

University of Florida

Public Address Systems, by George Haug, student; Problems Encountered in Taking a Transmission Line Inventory, by Craig Huffer, student. May 18. Att. 12.

Georgia School of Technology

Inspection trip through the Fox Theater. May 2. Att. 29.

Election of officers: F. T. Meiere, chmn.; E. C. Wagner, vice-chmn.; W. W. Ensminger, secy.-treas. May 16. Att. 53.

Harvard University

Some Phases of Institute Work, by I. E. Moultrop, Edison Elec. Ill. Co. of Boston, vice-pres. A.I.E.E. Election of officers; F. W. Roberts, chmn.; R. H. Packard, secy.; R. A. Ward, senior rep.; S. Smith, vice-chmn. May 23. Att. 16.

University of Idaho

Telephone Service, by Mr. Hadley, Interstate Telephone Co. Banquet. May 3. Att. 25.

Election of officers: H. R. McBirney, chmn.; Wm. Clagett, vice-chmn.; Fred Quist, secy.-treas. May 13. Att. 18.

University of Illinois

Election of officers: J. C. Wheeler, chmn.; P. S. Bickenbach, vice-chmn.; D. Bergelis, secy.; H. W. Bieritz, treas. May 11. Att. 19.

Dinner. May 15. Att. 16.

The Inversion of D-C. Into A-C. by Use of the Thyratron, by Dr. Reich. May 17. Att. 60.

Iowa State College

Election of officers: Glenn Lyshoj, chmn.; R. Allbright, vice-chmn.; Robert Doonan, secy.; Truman Eppert, treas. May 11. Att. 30.

Kansas State College

Conditions in Russia, by C. R. Bradley. Joint meeting with Univ. of Kansas Branch. May 5.

Giant Radio Tubes, by A. C. Hebert, student. May 12. Att. 57.

Airship Mooring Masts, by A. B. Niemoller, student; New Developments in Photoelectric Cells, by D. A. Bly, student. May 12. Att. 30.

Election of officers: S. R. Mudge, pres.; G. D. Ferguson, vice-pres.; B. E. Hammond, recording secy.; J. P. Kesler, treas.; A. E. Paige, marshall. May 19.

University of Kansas

Election of officers: R. C. Jackson, chmn.; R. C. Ayres, vice-chmn.; John Doolittle, secy.; Warren Boast, treas. May 19. Att. 36.

University of Kentucky

Modern Methods for Oil Well Drilling, by O. T. Koppius. April 27. Att. 36.

University of Louisville

Sir Isaac Newton, by Harold Walter, student. Election of officers: C. B. Eldridge, chmn.; H. F. Walter, vice-chmn.; Frank Neuhouser, secy.-treas. May 20. Att. 20.

Marquette University

Business meeting. May 5. Att. 25.

Michigan State College

Chicago Radio Show, by R. T. Thompson, student. May 10. Att. 17.

University of Michigan

Annual banquet. May 26. Att. 43.

Milwaukee, School of Engineering of

Some Aspects of the Public Utility Situation in Wisconsin, by G. W. Post, Milwaukee Elec. Ry. and Lt. Co. Illus. May 11. Att. 112.

University of Missouri

Election of officers: A. E. Coffman, chmn.; R. C. Cunningham, secy.-treas. May 12. Att. 17.

Montana State College

Milestones in Electrical Progress, by Prof. C. F. Bowman. May 19. Att. 66.

Electrical Properties of Hardened Copper, by A. Hill and H. Lambdin, students. May 26. Att. 88.

University of Nebraska

Demonstration of telephone equipment by S. P. Grace, vice-pres., Bell Tel. Labs., Inc. May 11. Att. 94.

Helmholtz's Law and Its Application to Television, by R. Brackett. May 18. Att. 12.

University of Nevada

Development of a Course of Study in Illumination, by L. G. Gianini, Genl. Elec. Co. March 17. Att. 34.

Election of officers: Milton Murphy, chmn.; Raymond Robinson, vice-chmn.; Harry Dunseath, secy.-treas. April 25. Att. 8.

Newark College of Engineering

Electric Ranges, by Prof. A. A. Mims. May 16. Att. 34.

North Carolina State College

Subjects for Fall Convention Papers, by J. L. Ponzer, student; General Report on Fall Meetings, by G. E. Ritchie, student. May 17. Att. 26.

University of North Dakota

Facsimile Transmission as Used in Navy Radio Sets, by John Gilhooley. May 4. Att. 14.

University of Notre Dame

Commercial Engineering or Engineering Economics, by Mr. DeQuine; Relativity, by J. A. Caparo, counselor. Election of officers: F. J. Lennartz, chmn.; Wm. H. Fromm, vice-chmn.; A. V. Alvino, treas.; J. K. Carnes, secy. May 10. Att. 62.

Ohio University

Election of officers: J. F. Hoskinson, chmn.; Wm. B. Cooper, vice-chmn.; E. H. Pryor, secy.-treas. May 11. Att. 37.

Oklahoma A. & M. College

Business meeting. May 9. Att. 10.

Oregon State College

Election of officers: John Mather, pres.; Bob Blasen, vice-pres.; L. Pennell, secy ; G. Manke, treas. May 2. Att. 20.

Development and Progress of Steam Power, by W. F. Hynes, Genl. Elec. Co. Illus. May 5. Att. 47.

A Modern Radio Test Kit, by H. Beckendorf, student; Directional Antennae and Their Operation, by M. Kofoid, student. May 16. Att. 30.

Joint meeting with the Portland Section at which the following papers were presented by students: Steam vs. Electric Drive for Sawmill Operation, by E. A. Buckhorn; A New Wattmeter for Communication Circuits, by K. R. Eldredge; Progress in the Electrical Measurement of Sound Absorption, by F. A. Everest; An Investigation of Field Strength Variations at Broadcast Frequencies, by G. S. Feikert. May 21. Att. 125.

University of Pittsburgh

Economic Value of Research, by Mr. Grondahl, Union Switch & Signal Co. May 5. Att. 100.

A New Type of Automobile Tire, by D. E. Trieber, student. May 12. Att. 100.

Rensselaer Polytechnic Institute

Development of Teletypewriter Systems, by P. D. Bryan, N. Y. Telephone Co. Election of officers: R. E. McAdam, chmn.; J. J. Korkoss, vice-chmn.; E. W. Knight, secy.-treas. April 19. Att. 305.

Rose Polytechnic Institute

Election of officers: J. C. Dalrymple, chmn.; G. T. Lautenschlager, secy. May 25. Att. 17.

South Dakota State School of Mines

The Western Union Program, by Mr. Blewitt, Western Union Telegraph Co. May 10. Att. 32.

University of South Carolina

Distribtuion of Power in South Carolina, by Senator T. B. Pearce. Banquet. May 5. Att. 30.

Story of the Motor Pump, by W. R. Humphlett; Electrical Therapeutics in Industry, by D. W. Cardwell; Short Wave Radio, by A. W. Obenschain; Some Marvels of the Universe, by W. S. Smith; Baltimore and Ohio Centralizes Traffic Control, by J. D. Martin, all students. May 12. Att. 36.

University of Southern California

Mercury Arc Rectifiers, by Mr. Fewcuey, Genl. Elec. Co. May 11. Att. 27.

Election of officers: R. R. Moore, chmn.; H. A. Peterman, vice-chmn.; Mr. Bailey, secy.; H. West, treas. May 18. Att. 33.

The Future of the Engineer, by Carl Heinze, Los Angeles Bureau of Water and Pwr. May 19. Att. 35.

Southern Methodist University

Election of officers: Porter Lindsley, Jr., chmn.; M. P. Jones, vice-chmn.; N. K. Read, secy.-treas. May 18. Att. 11.

Social gathering. May 28.

Texas A. & M. College

Discussion. May 19. Att. 50.

University of Texas

Electric Rates in Texas, by L. M. Curry, student. May 12. Att. 15.

Election of officers: Frank Sperry, pres.; J. R. Cutler, vice-pres.; Wm. Garrett, secy.-treas.; L. Baker, corres. secy. May 14. Att. 15.

University of Utah

A Stroboscopic Device for Studying Rotary Motion, by W. S. Nishiyama and K. M. Neilson, students. Demonstrations. May 26. Att. 43.

Virginia Polytechnic Institute

Life and Works of Thomas A. Edison, by P. H. Cross. Illus. May 12. Att. 46.

University of Virginia

Election of officers: T. J. LoCascio, pres.; C. E. Stahl, vice-pres.; G. K. Carter, secy.; J. W. Bowles, treas. May 23. Att. 11.

University of Washington

Modern Switchgear Equipment, by K. L. Howe, Westinghouse Elec. & Mfg. Co. Election of officers: W. Ryland Hill, chmn.; Earl Hathaway, vice-chmn.; Archie Adams, secy.-treas. May 12. Att. 14.

Cushman Power Development, by J. V. Congwer, Engr., City of Tacoma. May 19. Att. 31.

Washington State College

Discussion. May 13. Att. 9.

Election of officers: Paul Hand, pres.; A. McDougald, vice-pres.; Dick Wilson, secy.; G. Martinson, treas. May 24. Att. 17.

Washington University

Election of officers: Mr. Keiser, chmn.; Mr. Mendel, secy.-treas.; Mr. Maull, vice-pres. May 19. Att. 25.

Worcester Polytechnic Institute

Testing of High Voltage Transformers, by A. M. Tarbox, Westinghouse Elec. & Mfg. Co. Election of officers: W. E. Bass, chmn.; F. M. Potter, vice-chmn.; C. S. Brewer, secy.; H. A. Hammer, treas. April 25. Att. 32.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

FOREMAN OR CHIEF ELECTRICIAN, expert armature winding, motor repairs, and trouble. Install wiring systems for light and power. Extensive practical experience. D-657.

E.E. GRAD., 1927, Univ. of Wis., 30, married, 6 yr. experience in transformer, relay and meter testing, switchboard installations, outdoor substation construction and drafting, industrial pwr. and lighting layouts, inspection, and estimates. Location, Middle West preferred, others considered. D-1071.

GRAD. E.E., 29; 5 yr. supervisory construction, design, estimating and field engg. experience on super-power plants and substations; 4 yr. industrial pwr. plant operation. Electrical construction and maintenance experience; railway electrification construction experience. C-4428.

GRAD. E.E., 1927, single. 3 yr. construction and engg. work on ry. signals, train control, and small power plants. 2 yr. test dept. of large pwr. company. Desires connection with construction, industrial or utility concern or as instructor in mathematics or E.E. subjects. Available at once. Location, immaterial. C-6439.

Design and Development

E.E. GRAD., 29, single, 5 yr. experience including 6 months testing a-c., d-c. machines, $4^1/_2$ yr. design 5 to 2,000 hp. a-c. and d-c, motors for industrial and special applications. Thoroughly familiar with motor quotations, estimates and applications. Desires position with utility, mfg. or construction firm. Location, U.S. Available immediately. D-944.

DISTRIBUTION ENGR., MFG. ENGR.; E.E. grad., 27, married, 6 yr. experience with large elec. mfg. company, desires position as transformer design engr., mfg. engr., or as elec. engr. for utility or holding company. Available immediately. D-963.

ENGR., electrical-welding: 13 yr. experience design and application resistance welding equip. 4 yr. full charge design and research. Considerable experience on arc welders. Knows shop practise under mass production conditions. Also had wide experience as sales engr. Held 2 positions as sales mgr. and has nation-wide dealer contacts. D-994.

DESIGNING ENGR., E.E. grad., 32, married, 8 yr. experience in designing and selling instrument and dry type distribution transformers. Desires employment with utility or mfg. concern, selling or engg. Available immediately. Location, immaterial. Best references. D-1015.

E.E. GRAD., 28, married, desires position in design and development or teaching. One yr. Westinghouse Student Course; 6 months Westinghouse Design School; $1^1/_2$ yr. design of fractional hp. motors; $2^1/_2$ yr. design of industrial motors. Available at once. Location, U.S. C-5051.

ELEC.-MECH. ENGR., 30, married, college grad. with usual abilities for elec. relay circuits (autom. teleph., control, alarm systems, signaling) resourceful mech. designer on small apparatus, 5 yr. engg. experience. Available immediately. Location, immaterial. C-8373.

E.E. GRAD., 1928, Rensselaer Poly. Inst., 28 yr. single, 4 yr. experience in genl. elec. pwr. plant and substation design and right-of-way and operating budget work with utility. Desires to enter such a field as plant engg. or industrial or economic planning. Available at once. D-1061.

GRAD. E.E., 29, single, 7 yr. experience designing and installing elec. and mech. equip. for large steel company. Highest references. Location, immaterial. Available on short notice. D-1037.

MECH.-ELEC. ENGR., 32, 4 yr. Cornell design instructor; 5 yr. Allis-Chalmers design; liberal shop experience; 5 yr. cooperative apprenticeship. Will consider anything, anywhere, now available. Salary open. D-122.

Draftsmen

E.E., 1931, 24, married. Experience: Drafting, grad. of 5 months training in large utility, 6 months in utility research dept. Interested in illumination, substation, or distribution. Available at once, and in need of work. Any location. D-1041.

Executives

MECH. & ELEC. ENGR., grad., married, 20 yr. experience in design, construction, and operation of mill and smelter in the ferrous and nonferrous industries, with excellent record in plant improvement and lowering production costs, desires responsible position with industrial plant engg. firm or sales office. B-7343.

SUPT. ERECTOR, 28, paper mill and printing mchy., experimental and developing automatic mchy., 7 yr., has legal training; executive and management experience, inspecting and auditing, thoroughly familiar with elec. meter lab. Wants any position to prove his capabilities. D-965.

TECH. GRAD., 33, married. Eleven yr. experience covering all branches of elec. measurements in lab. of large mfg. company. Desires position with utility in meter or transmission and distribution dept. Available on short notice. Location in East preferred. D-981.

EXEC. OR CONSULTING ENGR., mech. and elec., 43, American, college education. Past 3 yr. with prominent engg. organization correlating design engg. work for large central station and industrial pwr. plant projects. Previous experience included building, testing, and operating similar plants. Exceptionally broad experience. Available July 1. D-986.

ASSOC. ELEC. ENGR., 38, married, tech. education, 9 yr. with utility as distribution engr., estimating, inspection, underground construction, contact man, developed plans and records division; 6 yr. research and development on protective devices. Available immediately, location, immaterial. C-8958.

ELEC. ENGR., 34. Ten yr. experience covering design, cost estimating and equipment specifications of pwr. plants, copper refineries, indoor, and outdoor substations, transmission lines, and industrial work. Also 1 yr. experience as asst. research with cable company. C-5473.

E.E.—M.E. GRAD., married, 20 yr. experience, desires connection, engr., asst. exec. where efficient use of pwr. and plant is needed; also teaching. Experienced, design of plant; modern design, manufacture, installation of equipment; plant maintenance; electrical, equipment layouts. Special training, experience, metallurgy, concrete, elec. arc welding, building construction, specifications, business mgmt., sales. C-4519.

E.E., 10 yr. experience. Executive ability. Seven yr. operation and maintenance interconnected pwr. system; relay and communication problems; design and installation automatic equipments. Three yr. with large mgmt. company, including $1^1/_2$ yr. in Mexico on economic studies, generation and transmission projects, and $1^1/_2$ yr. electrolysis investigations domestic natural gas lines. D-1003.

EXEC. OR ASST., 18 yr. broad experience in utility, mfg., industrial surveys, and mgmt. problems. Through proper application of engg. analysis and principles, can effect economies in operation and control. Capable organizer. Profitable asst. to busy exec. Salary secondary to opportunity. B-9122.

EXEC. ASST. available, 12 yr. utility experience. Grad. E.E., 37. Appraisal work of pwr. plants, substations, transmission and distribution systems, rate investigations covering industrial service, residential and commercial, cost studies, statistical research, operation in plant, equipment and lines. G.E. test course. B-9782.

E.E., married, E.E., M.E. 22 yr. experience, designing, construction pwr. plants, substations, transmission, distribution systems, industrial plants. 3 yr. charge purchasing engg. equip., foreign interests. 3 yr. executive experience charge engg. dept. large utility syndicate. English, German, Russian, Armenian languages. Available immediately. D-84.

GRAD. E.E., 32, 10 yr. experience, of which over one-half was spent with large utility in engg. and supervisory work and the remainder with mfr. of high tension switching equip. as assistant gen m r. Available on short notice. Location, immaterial. D-745.

ASSOC. A.I.E.E., B.S. in E.E. Iowa State College, 1929, 32, single, worked way through school, 3 yr. Westinghouse insp. and test, including c.c. regulators, c.l. reactors, dimmer reactors, instrument transf., distribution and power transf. a-c. welding outfits, misc. equipment. Interested in supervision, developments, application engineering, rural electrification. References. Location, immaterial. Available immediately. D-1081.

E.E., 33, married, desires position, mfgr. of radio or public address systems, broadcasting station, or carrier dept. of elec. pwr. co. 4 yr. design, construction, operation, testing of equipment for electric pwr. stations. 6 yr. installation, wiring testing radio broadcast, telephone and telegraph repeaters, and carrier equip. Excellent references. D-733.

E.E. wants position. Wide experience in elec. field, engg., mfg., sales, erection and operation of storage batteries. E.E. Grad. from Mass. Inst. of Tech. C-4109.

GRAD. ENGR., 35, with 10 yr. experience in the engg., operating, and executive depts. of a utility, desires position as jr. exec. or office mgr. in a mfg. concern or utility. Speaks Spanish and has fair knowledge of acctg. B-2470.

Instruction

GRAD. E.E., 35, married, B.S. in E.E. at M.I.T. 1920. Entire experience since then in E.E. teaching and E.E. industrial work. Good ability and personality. Desires work in E.E. teaching. Salary open. C-2826.

E.E. GRAD., 1925 Ohio State, 32, married, experience; pwr. plant and substation operation and maintenance, distribution (a-c. and d-c.), relay engg., pwr. plant and substation design and supervisory construction experience with contractor, high school instructor. Desires position with future. Available immediately. D-996.

E.E. GRAD., 26, single, desires position in design and development or teaching. Westinghouse student course. Westinghouse design school. Rectifier design. Available at once. Location, immaterial. D-988.

E.E. DESIGNER, 31, married, 4 yr. experience in construction, 3 yr. experience in design of pwr. stations, substations and industrial control, 1 yr. instructor in large univ. and 8 months Westinghouse test course, desires position in engg. office, field construction or teaching. C-5734.

GRAD. E.E., 1926, single, 29, G.E. Test Course, 5 yr. experience on proposition work and specifications as commercial engr. with large elec. manufacturing concern. Desires to enter teaching field in U.S. Electrical subjects, physics, mathematics, or English. Will be interested in opportunity for advanced study. D-1005.

INSTRUCTOR OR ASST. PROF., 38, 8 yr. instructor in E.E., radio, physics in univ.; 5 yr. commercial experience, lighting, pwr., and radio installations, research and design. At present research assoc. in physics in post grad. school of well known univ. Available for next September. C-6302.

DOCTOR OF ENGG., J.H.U., '32, 23, single. Research experience in fields of radio, a-c. and d-c. measurements and high voltage insulation studies. Desires research or engg. position, also teaching in E.E., mathematics, or physics. Location, immaterial. D-1040.

ASSOC. PROF. E.E. B.S., and E.E. deg., 42. 5 yr. teaching experience, 11 yr. design, engg. and exec. experience in radio and communication. Highest references. Available immediately. Location, immaterial. D-1062.

M.S. in E.E. and PHYSICS, 31, married, coached mathematics, physics, E.E. while undergraduate, senior math. asst., some teaching with grad. study. 6 yr. industrial motor design, research, also mfg. practise, motor control. Desires to teach E.E. primarily, charge or part charge of research; can also teach drafting, machine design. Available season 1932–33. D-980.

Junior Engineers

E. E. GRAD., Purdue, 1931, single, 24. Seven months in training course of a large utility company. Experienced in stenographic and secretarial work. Desires position with future in mfg. concern or utility. Available at once. Location, immaterial. D-437.

RECENT COLUMBIA UNIV. GRAD., B.S., 1931, E.E. in 1932; Italian born, but American citizen, desires engg. or teaching opportunity. D-894.

E.E. GRAD., 1928. Iowa State Coll., 25, single. $1^1/_2$ yr. experience designing of rural lines, 1 yr. experience designing distribution city lines, 1 yr. experience handling joint contracts between elec. and telephone companies. Desires position with utility. Location, Middle West or West. Available immediately. D-978.

JUNIOR ENGR., E.E. GRAD., 31, married, B.S. 5 yr. operating and maintenance utility, 14 months Westinghouse test, 2 yr. Westinghouse motor sales dept. Good experience on motors and control. Some civil engg. experience. D-1025-321-C-2-San Francisco.

E.E. GRAD., '23, Sc.M., M.I.T. and Harvard '28; Sc.D. M.I.T. June '32, thesis in network synthesis; 38, single; 8 yr. practical experience, pwr.-business-and communication engg. Two yr. testing course. Speaks Swedish, English, German; reading knowledge French. Desires position preferably in line of communication engg. Available June 15th. Location, immaterial. D-747.

E.E. GRAD., 27, married. Design of pwr. plant, substation and pwr. transmission lines. Industrial remote control. Also broad experience on appraisals of utilities. Available immediately. Location, immaterial. D-679.

E.E. GRAD., 1932, Univ. of Nebraska, single, 22. Desires engg. work in commercial field. Available now. Location, immaterial. D-997.

MECH.-ELEC. ENGR., 1930 tech. grad., 2 yr. engg. experience manufacture of elec. wires and cables, machine shop work, also surveying and drafting work. Will consider any job or position offered. Available immediately, anywhere, at minimum living salary. Single, 26, and in need of work. D-66.

GRAD. E.E., 1929, single, 23. Fifteen months student engr. on G.E. test. Some test, drafting and switchboard construction experience before graduation. Interested in position with firm doing consulting or construction work or with utility or manufacturer. Available at once. Location, anywhere in U.S., but New England preferred. C-8028.

1931 GRAD., B.E.E. cooperative course. 25, single. Experience includes elec. maintenance. const., drafting, and laboratory work. Location, immaterial. Available at once. D-1060.

EXECUTIVES If you can possibly use an ambitious young E.E. with a B.S. from Brown Univ. who, together with tech. knowledge, combines a knack for managing and publication work your correspondence is requested. The very best references can be furnished. D-742.

RECENT M.I.T. GRAD. (S.B., S.M.), in E.E. 28, cooperative training with Stone and Webster Inc., desires opportunity with future in production or construction field. Previous business experience. D-1047.

B.S. in E.E., 1931, Armour Tech., 23, single, experience: 6 months telephone, 3 months G.E. student, 7 months utility student, speaks German well, wants work, salary secondary, location, immaterial. D-1072.

1931 GRAD. IN E.E., B.S. from Clemson Agril. College, 25, single. Desires work with utility.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St. San Francisco	205 West Wacker Drive Chicago	31 West 39th St. New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

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Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

mfg. concern or construction corporation. Available immediately. Location, immaterial. D-400.

E.E. GRAD., Purdue, 1930. Single, 24. 2 yr. communication experience and training with Am. Tel. & Tel. Co., including outside line and cable construction; test room operation, carrier systems, etc., also Morse telegraphy. Not afraid of hard work. References gladly furnished. Available immediately to go anywhere. D-1075.

E.E. GRAD., 26, single, excellent physical condition. One yr. experience installation, testing telephone exchange equipment. Three yr. teaching public school. Graduate small business col. Considerable training, experience, selling. Not afraid of hard work. Interested in position requiring engineering knowledge or teaching experience. Excellent references. Correspondence invited. Location, immaterial. Available immediately. D-1076.

E.E. GRAD., B.S. in E.E., cooperative course, Drexel Inst., 1931. M.S. in E.E., M.I.T., 1932, 23, single. Two yr. experience in plant dept. of Bell Telephone Co. of Pa. Desires engg. or teaching position. Location in East preferred. Available immediately. References upon request. D-1087.

Maintenance and Operation

CONSTRUCTION AND MAINTENANCE SUPT., 37, married. Grad. E.E. Thirteen yr. experience in utility field, particularly in engg., construction and maintenance of distribution and transmission substations. Desires position with large utility with responsibility for the construction, operation, and maintenance of substations. B-2885.

E.E., 31, married, tech. school. Eleven yr. experience, C.G.E. Test 4 yr. Service-maintenance - operation - construction - hydro elec. plants, paper mill-municipal and public utility hydro-plants. Will go anywhere in Canada. D-982.

PRACTICAL ELEC. CONSTRUCTION CHIEF, 32, 14 yr. experience in elec. construction work and also maintenance work. Last 4 yr. in Latin-America. Can speak Spanish and German well. Available immediately. Location, immaterial. C-2101.

E.E. GRAD., married, 8 yr. steam plant operation and maintenance, and factory maintenance. Now unemployed. Location preferred, Middle West or Western. C-8522.

Research

DEVELOPMENT-RESEARCH ENGR., experienced in the design of apparatus in the development of railroad signaling, automatic train control, and centralized traffic control systems, telephone and telegraph systems for commercial use and in connection with train dispatching. Also in making mathematical studies and theoretical investigations. D-995.

MEASUREMENT AND CONTROL SPECIALIST seeks connection with commercial lab., utility or mfr., in capacity of developing or investigating engr. or consultant. Wide and extensive experience with all types of elec. instruments, precision measurement, standardization, and automatic control. Also experienced in pyrometry and pneumatic control. B-7245.

E.E. GRAD., Carnegie Inst. 1921. Graduate work, Carnegie Inst., Univ. of Pittsburgh, 34, married. Experience, telephone switchboard installation, railway appraisal, power plant operation. Two yr. general development lab., Western Elec. Co. Nine yr. research dept., Union Switch & Signal Company doing development work on train control, copper oxide rectifiers. Location preferred, Pittsburgh. D-1031.

Sales

SALES ENGR., grad. E.E. with excellent background of both sales and advertising, desires connection with mfr. Location, Middle West preferred. Experience in industrial advertising in addition to engineering and selling of elec. equip. Excellent references. Age 33, married. B-8614.

SALES ENGR., 40, tech. grad., single, 20 yr. experience selling elec. equip. for industrial plants including utility affiliation involving the sale of central station service to industrial plants and supervising the activities of industrial pwr. salesman. Desires permanent connection preferably as representative of mfr. in an industrial center. C-5546.

E.E. GRAD., 1931, southern univ., married, 21, experience: sales engr., radio service, public address systems, production work location, and estimates. College major hydroelectric systems and transmission. Desires position in above field, especially sound engr. or location work. U.S. or foreign location. D-983.

PWR. SALES ENGR., E.E. grad., 1928, 25, married. One yr. Westinghouse Test Course, 3 yr. with large engg. corporation; pwr. plant and substation design and layout, contact man with elec. mfrs., extensive industrial engg. Desires permanent position as pwr. sales engr. or other engg. work. Excellent references, location, immaterial. C-4303.

E.E., 27, single, 28 graduate. Fifteen months G.E. Test. Two yr. sales experience with elec. servicing concern. Desires position with utility or mfg. concern. Has following with all eastern utilities. Eastern location advantageous. D-974.

ENGR., E.E.-Mech. grad. Yale Univ., 39, married. Eighteen yr. experience on machine tools, G.E. Test and engg. application, sales and sales promotion of elec. equipment. Qualified engr. for research and marketing, also application engr. for elec. and mech. equipment. Available immediately. Location preferred, New York Territory. D-1074.

SALES ENGR., 30, single, E.E. grad. of a reputable 1 yr. engr. school. Five yr. experience selling industrial and central station instruments. Desires position as salesman with a high grade mfg. concern. No particular line desired. Will travel, location, immaterial. C-1570.

Membership

Recommended for Transfer

The board of examiners, at its meeting of June 15, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed with the acting national secretary at once.

To Grade of Fellow

Gay, Frazer W., asst. engr., United Engineers & Constructors, Inc., Newark, N. J.

To Grade of Member

Allen, R. W., distribution engr., Narragansett Elec. Co., Providence, R. I.
Carrick, John F. C., sales agent, Genl. Elec. Co., Niagara Falls, N. Y.
Chetham-Strode, A., station design engr., Dallas Pwr. & Lt. Co., Texas.
Coover, Mervin S., prof. of elec. engg., Univ. of Colo., Boulder.
Hamburger, Ferdinand, Jr., instructor, Johns Hopkins Univ., Baltimore, Md.
Harrison, S. H., supt., Vulcanite Portland Cement Co., Phillipsburg, N. J.
Ketchum, Wm. D., engr., Commonwealth & Southern Corp. of N. Y., Birmingham, Ala.
Konn, Felix, design section, motor division, Genl. Elec. Co., Erie, Pa.
Lambert, Alexander B., elec. engr., Crompton Parkinson, Ltd., Toronto, Ont., Can.
Laurtizen, Carl W., asst. prof. of elec. engg., Valparaiso Univ., Ind.
McFarland, T. C., assoc. prof. of elec. engg., Univ. of Calif., Berkeley.
Morecock, Earl M., coordinator of elec. students Rochester Athenaeum & Mechanics Institute, N. Y.
Penniman, A. L., Supt. of steam stations, Consolidated Gas, Elec. Lt. & Pwr. Co., Baltimore, Md.
Price, John R., prof. of elec. engg., Univ. of Wisconsin, Madison.
Rice, Harold F., asst. prof. of elec. engg., Univ. of No. Dakota, Grand Forks.
Robertson, Burtis L., asst. prof. of elec. engg., Univ. of Calif., Berkeley.
Skolfield, Wm. K., designing engr., Genl. Elec. Co., Bridgeport, Conn.
Stover, James R., elec. engr., W. S. Barstow & Co., Inc., Reading, Pa.
Wilson, Henry E., relay engr., Carolina Pwr. & Lt. Co., Raleigh, N. C.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before July 31, 1932.

Boland, W. I., 801 Sutter St., San Francisco, Calif.
Bottimer, G. W., Consumers Pwr. Co., Grand Rapids, Mich.
Bowman, J. H., Purdue Univ., Lafayette, Ind.
Burckmyer, L. A., Jr., Cornell Univ., Ithaca, N. Y.
Cohn, D. E., R. R. Commission of South Carolina, Columbia.
Cook, I. M., Shell Oil Co., Los Angeles, Calif.
Crum, E. R., Crum Elec. Co., Memphis, Tenn.
Davenport, L. B., Houston Armature Wks., Texas.
Dockendorf, J. P., Airways Radio Sta., U.S. Dept. of Commerce, Sweetwater, Texas.
Geyer, P. W., Lackawanna & Western R. R. Co., Hoboken, N. J.
Hucks, George J., Pacific Tel. & Tel. Co., San Francisco, Calif.
Kajiura, K., Japanese Gov. Ry., N. Y. City.
Lambert, J. L., Tooke Bros., Montreal, Que., Can.
Maier, J., 1830 2nd Ave., N. Y. City.
Manucia, J. H., Manhattan Elec. & Radio Corp., N. Y. City
Meinders, J. J., New York Edison Co., N. Y. City.
Neubacher, L. L., Pacific Gas & Elec. Co., San Francisco, Calif.
Noble, D. E., Conn. Agri. Col., Storrs.
Nye, E. C., (Member), Instrument Serv. Labs., St. Louis, Mo.
Powell, C. A., 816 Blvd., Westfield, N. J.
Sholl, R. R. (Member), N. Y. & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.
Skvorzoff, M., 200 W. 111th St., N. Y. City.
Trueblood, R. O., Univ. of Wyoming, Laramie.
23 Domestic

Foreign

Ali, S. N., H. H. Gov., Patiala State, Punjab, India
Beljavsky, A. G. (Member) North-Caucas Inst. of Energetics, Novocherkassk, U.S.S.R.
Bryant, A., Kenya & Uganda Governments, Nairobi, Kenya Colony, E. Africa.
Chan, S., 33 Wan Tsai Rd., Hong Kong, China.
Crisp, H. K., Municipalities of Bowral and Mittagong and Shire of Nattai Bowral, New South Wales, Australia.
Gokli, K. N., R. Gokli & Co., Matunga, Bombay, India.
Gomez, A., Chilean State Rys., Valparaiso, Chile, So. Am.
Headland, H., Public Wks. Dept., Waitaki Hydro, South Island, N. Z.
Hickey, M. G., Hackbridge Elec. Construction Co., Hersham, Walton-on-Thames, Surrey, Eng.
Perry, A. M., Hachbridge Elec. Construction Co., Surrey, Eng.
Sawhney, B., Assoc. Electrical Industries, Lahore, India.
Thampan, K. C., Pykara Construction Wks., Glen Morgan P. O., The Nilgiris, So. India
Verma, R. P., Gaya Engineering & Elec. Pwr Supply Co., Ltd., Gaya, India.
13 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Archbold, Earl J., Box 2641, Birmingham, Ala.
Blugerman, L. N., 227 N. 18th St., Phila., Pa.
Bugg, Vernon, 736 Transp. Bldg., Washington, D. C.
Callen, R. J., Brunswick Recording Lab., 799 7th Ave., N. Y. City.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.
Palit, Hari-Charan, 151 Ganesh Mohal, Benare City, India.
Pearson, Ernest, 209 Brewster Rd., Scarsdale, N. Y.
Rogge, C. A., Consumers Pwr. Bldg., Jackson, Mich.
Scanlon, D. L., KFPW, Ft. Smith, Ark.
Schwartz, Carl, 410 Cathedral Pkwy., N. Y. City.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Ness, L. G., 2105-6 Sterick Bldg., Memphis, Tenn.
Vetri, L., Western Elec. Co., Inc., 100 Central Ave., Kearny, N. J.

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during May are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

GALVANISCHE ELEMENTE UND AKKUMULATOREN. By C. Drucker and A. Finkelstein. Leipzig, Akademische Verlagsgesellschaft, 1932. 425 p., illus., 10x7 in., cloth, 36 rm.—Intended for the manufacturer of dry cells and storage batteries who wishes an account of the fundamental theory as a basis for research work, and is also interested in a discussion of methods of manufacture. Raw materials, methods of construction, uses, and properties of dry cells and accumulators, are described in a practical way. One third of the book is an extensive index to German, British, and American patents since 1919.

GASOLINE AUTOMOBILE. By B. G. Elliott and E. L. Consoliver, 4 ed. N. Y. and Lond., McGraw-Hill Book Co., 1932. 605 p., illus., 9x6 in., cloth, $3.00.—The fundamentals of automobile construction, maintenance, and operation are set forth in this work with sufficient fulness for the needs of the owner, operator, repair man, and student. The text is clear and explicit and amply illustrated with photographs and drawings. The revision has been thorough and complete.

HANDBOOK OF THE COLLECTIONS ILLUSTRATING LAND TRANSPORT. III, Railway Locomotives and Rolling Stock. Part 1. Historical Review. By E. A. Forward. London. South Kensington Science Museum, 1931. 99 p., illus., 10x6 in., paper, 2s6d.—This pamphlet provides a very useful, concise review of the development of the locomotive and the railroad car in the British Isles. The locomotive occupies most of the space, and its evolution is expertly traced from Trevithick's experiments in 1801 to the latest types. Electric and internal combustion engines are included.

KOLLOIDCHEMISCHE TECHNOLOGIE. By R. E. Liesegang, 2nd ed. Dresden and Leipzig, Theodor Steinkopff, 1932. 1085 p., illus., 11x7 in., paper, 68 rm., cloth, 72 rm.—An extensive review of practical applications of colloid chemistry, in the form of essays by a number of specialists. The subjects considered include among others lubricants, textiles, rayon, paper, plastics, electrical insulating materials, Portland cement, water, sewage, petroleum emulsions, metallurgy, and flotation. The articles are concise and up to date and contain numerous references to sources. A useful survey of its subject.

HIGH-SPEED DIESEL ENGINES. By P. M. Heldt. Phila., P. M. Heldt, 1932. 312 p., 9x6 in., cloth, $4.00.—Although there is a number of books on Diesel engines, this is the first American treatise specifically for the high-speed oil engine for automotive use. It aims to give an orderly condensed review of the research work done in America and Europe on problems connected with design, with descriptive data and illustrations of typical examples of the various sub-classes. The book brings together an amount of material of interest to designers and experimenters, especially for automobile and aircraft engines, which heretofore has been widely scattered.

NORMALISATIONS, SPÈCIFICATIONS ET PRESCRIPTIONS TECHNIQUES, 1930–31. Union des Syndicats de l'Électricité, Paris, 1931. 1024 p., 9x6 in., cloth, 50 fr.—A collection of rules and standards governing the construction, erection, and operation of electrical equipment as in force in France. Includes standards of the International Electrotechnical Commission, the French Electrotechnical Commission, the Union des Syndicats de l'Électricité, and other associations of engineers and manufacturers, and of government agencies. Convenient and comprehensive.

PRINCIPLES OF PUBLIC UTILITIES. By E. Jones and T. C. Bigham. N. Y., Macmillan Co., 1931. 799 p., 9x6 in., cloth, $4.25.—A text on the economics of public utilities, a text-book for students and a manual for officials, engineers, and others interested in public utility problems. The discussion is confined to the utilities supplying electric light and power, gas, street railway service, telephone service, and water. The subjects treated include regulation, valuation, rates, finances, combinations, public ownership, and other outstanding problems.

TABLES ANNUELLES DE CONSTANTES ET DONNEÉS NUMÉRIQUES DE CHIMIE, de Physique, de Biologie et de Technologie, 1929, v. 9. Paris, Gauthier-Villars et Cie; N. Y., McGraw-Hill Book Co., 1931. 1607 p., 11x9 in., cloth, $12.00.—With this issue this important reference work is again upon an annual basis. The present volume contains all the constants and numerical data published during 1929 in the fields of chemistry, physics, biology, and engineering. The series is an indispensable supplement to the "International Critical Tables" and is essential to every research worker. Text in both English and French.

TRANSFORMATEURS DE MESURE ET RELAIS DE PROTECTION. By C. Bresson. Paris, Dunod, 1932. 293 p., illus., 10x6 in., cloth, 91 fr.—Two important questions in distribution systems are discussed. The first half discusses the characteristics of instrument transformers, the qualities that effect their efficiency, and their use in distribution systems. The remainder of the book describes the principal types of circuit breakers and protective relays and illustrates their uses.

ÜBER DEN SCHALLSCHUTZ DURCH BAUKONSTRUKTIONSTEILE. (Beihefte zum Gesundheits-Ingenieur, Reihe 2, Heft 11.) By H. Reiher. München and Berlin, R. Oldenbourg, 1932. 28 p., 12x9 in., paper, 4.80 rm.—By tests in laboratory and buildings the soundproofing properties of over 200 old and new structural elements were determined accurately. The results are presented in tables, accompanied by an account of the theory of sound propagation and of transmission, and a description of the methods of measurement used in this investigation. General conclusions are drawn from the tests and minimum requirements suggested.

AIRCRAFT YEAR BOOK, v. 14, 1932. By Aeronautical Chamber of Commerce. N. Y., D. Van Nostrand Co., 1932. 626 p., illus., 9x6 in., cloth, $6.00.—Part I records outstanding events of the year's aviation, American and elsewhere; part II deals with engineering and manufacturing progress and illustrates American aircraft and engines; part III is a chronology of important contests and records. The remainder gives useful statistics and directory of officials, associations, etc. A convenient summary of all matters of aviation.

AM. SOC. FOR TESTING MATLS. INDEX TO PROCEEDINGS, v. 26–30, 1926–30. Phila., A.S.T.M., 1932. 251 p., 9x6 in., to members, cloth, $1.75; half leather $2.75; non-members (cloth $2.50, half leather, $3.50.—A full subject and authors' index to these proceedings of the society, for testing materials and the study of their properties. A supplement to the first 25 vols.

BARRAGES CONJUGUÉS ET INSTALLATIONS DE POMPAGE. By G. Laporte. Paris, Gauthier-Villars et Cie, 1932. 144 p., 10x7 in., paper, 35 frs.—An investigation of economic possibilities of increasing hydroelectric output by pumping water back to reservoirs with off-peak power; especially suitable where 2 or more plants upon 1 river are operated together. Feasible plans of pumping are discussed, and plant characteristics suited to each determined.

BIBLIOGRAPHY OF AERONAUTICS, 1930. Natl. Advisory Comm. for Aeronautics. Washington, D. C., U. S. Govt. Prtg. Office, 1932. 261 p., 10x7 in., paper, $0.50.—1930 literature including references to articles in principal world magazines. Alphabetized with authors and subjects in one listing. A continuation of a series which covers the subject from early times.

COLLOID CHEMISTRY, v. 4. Ed. by J. Alexander. N. Y., Chem. Catalog Co., 1932. 734 p., illus., 9x6 in., cloth, $11.50.—Concludes a series of valuable papers published by Dr. Alexander during past 6 years. Devoted to technological applications and items on colloid chemistry of cellulose, paper, explosives, sugar, and other carbohydrates; dyeing; rubber; plastics; tanning; paints; electroplates, etc.; solidified alcohol; fire extinguishers; water supply and sewage disposal.

DIELECTRIC. III. BREAKDOWN OF SOLID DIELECTRICS. By S. Whitehead, ed. by E. B. Wedmore. London, Ernest Benn, 1932. 346 p., illus., 9x6 in., leather, 30s.—This completes the survey of dielectric phenomena prepared by the British Elec. and Allied Industries Research Board. Is a critical summary of information available on dielectric phenomena with particular reference to the theoretical basis and failure of insulation in service. Includes bibliography.

EARTH DAM PROJECTS. By J. D. Justin. N. Y., John Wiley & Sons, 1932. 345 p., illus., 9x6 in., cloth, $5.00.—An endeavor to set forth the principles of design and construction useful to the engineer, illustrating applications by concrete examples. It opens with description of dam failures and the causes, treating of preliminary investigations and surveys, subsurface investigations, and materials and laboratory tests. Problems of design and construction are given in detail and various methods of building described. Ends with description of a number of representative dams. As the only such work in print, it fills a distinct need.

EINFÜHRUNG IN DIE THEORETISCHE ELEKTROTECHNIK. By K. Küpfmüller. Berlin, J. Springer, 1932. 285 p., illus., 10x7 in., cloth, 19.50 rm.—An introduction to elec. engg. theory intended to fill a field between elementary text and treatises upon specific applications. Confined to facts and methods required as a general background by the engineer interested in development of electricity. Holding to essential physical laws makes thoroughness possible in a book of moderate size.

ELEKTROTECHNISCHE GESELLSCHAFT, Frankfurt am Main, 1881–1931. Geschichtstafeln der Electrotechnik. Collected by S. Ruppel. Berlin-Charlottenburg, Verband Deuts. Elektrotechniker, 1932. 127 p., illus., 12x8 in., paper, 6 rm.—A memorial volume for the 50th anniversary of the Elect. Engg. Soc. of Frankfurt. A series of interesting tables of outstanding dates and developments on theoretical principles, generators, motors, machine tools, railroads, transmission lines, insulators, cables, switch-gear, power plants, lighting, storage batteries, meters, telephony, radio, etc. Statistics also are given showing the growth of industry.

ELEMENTS OF ELECTRICAL DESIGN. By A. Still. 2 ed., N. Y. and Lond., McGraw-Hill Book Co., 1932. 583 p., illus., 9x6 in., cloth, $5.00.—Presenting the elements of electrical design. Not to train designers, but to give students an understanding of fundamental principles in application to concrete designs. A new edition revised thoroughly for the trend toward higher operating voltages and improved efficiency.

FARADAY AND MAXWELL. (Deutsches Museum Abhandlungen und Berichte, Jahrg. 4, Heft 1.) By E. Cohn. Berlin, V.D.I.-Verlag, 1932, 29 p., illus., 8x6 in., paper, 90 rm.—An essay linking the lives and work of Maxwell and Faraday in a most interesting way, and showing how our present principle of energy through Maxwell's studies was evolved from Faraday's experiments.

GESCHLICHTLICHE EINZELDARSTELLUNGEN AUS DER ELEKTROTECHNIK, v. 3. By Elektrotech. Verein. Berlin, J. Springer, 1932, 125 p., illus., 9x6 in., cloth, $2.64.—Three interesting papers in a new volume of a series. Dr. Weicker gives a history of the development of insulators for overhead lines; Dr. Fischinger the early history of the Lauchhammer power plant, the first 100-kv. plant in Europe; and Dr. Poschenrieder gives interesting recollections of his experiences in the infancy of elec. engg.

ILLUSTRIERTE TECHNISCHE WÖRTERBÜCHER, Deutsch, Englisch, Französisch, Italienisch, v. 17. AERONAUTICS. Ed. by A. Schlomann. Berlin, V.D.I.-Verlag, 1932. 740 p., 10x7 in., cloth, 30 rm.—This volume follows the general plan of the series to which it belongs, with about 13,000 terms being arranged systematically; indexes in German, French, Italian, and English. Illustrated freely. Prepared with the assistance of a number of engg. soc. and firms, aviation boards, and govt. bureaus. Claimed superior to any dictionary available and welcome to translators.

Industrial Notes

Electric Heat Speeds Plant Growth.—Electric heat furnished by General Electric soil-heating equipment during the 1931–1932 season helped improve the quality of farm products, aided in getting them to market earlier, helped growers to a profit, and gave power companies an additional annual consumption of one and a half million kilowatt-hours of electric current, declared G. A. Rietz, in charge of the rural electrification section of the company, in a recent talk before rural electrification specialists of the Niagara-Hudson Power Company. The equipment, including cable and thermostats, was sold to farmers throughout the United States on an active commercial basis for the first time last season. The bulk of the power is used between sundown and sunrise, making it practically an offpeak load.

On the strength of sales activity in cooperation with central station representatives, and the testimony of thoroughly beneficial results, the demand for electric hot-bed equipment is expected to more than treble the kilowatt-hour load for the next growing season. "This estimate is based on the enthusiastic acceptance and adoption this past season, the present demands for the coming season, and the reports made on results by commercial growers. All these indications point to an additional 5,000,000 kilowatt-hours in annual consumption during the coming season by reason of new installations of this heating equipment," Mr. Rietz said.

A New Insulation.—A new chemical product which has practically all of the characteristics of rubber, but which is not affected by solvents, has been in commerical production for some time past. It is an olefin polysulfide reaction product known as Thiokol, and is manufactured by The Thiokol Corporation, Yardville, N. J. This product is made entirely of chemicals through a simple process and like rubber it is compounded and vulcanized in the processing of finished articles. Unlike rubber, Thiokol compounds do not age or perish in storage. Oxygen does not appear to affect it and the ozone generated during electrical corona tests does not cause deterioration. A number of leading electrical manufacturers are said to be testing Thiokol at present for use in the following applications: protective covering for underground low voltage cable; connections for oil filled cables in place of cement; submarine cables; ignition cables to protect against oils and corona conditions; transformer gaskets, high voltage cable covering in place of lead, and others.

New Tachometer.—A new direct-reading hand tachometer for testing r.p.m. machine speeds has been developed by the Amthor Testing Instrument Co., Inc., 309 Johnson St., Brooklyn, N. Y. It incorporates the new feature of automatic fixed reading whereby speed readings are automatically fixed on the dial after use. The dial reads directly in r.p.m., but all accessories are included so that "feet per minute" surface belt speeds can be taken. Various ranges can be had to directly measure speeds as high as 12,000 r.p.m.

U. S. Magnetic Products Corp. Elects M. B. Mervis.—According to a recent announcement, M. B. Mervis, formerly secretary-treasurer and general manager of the American Insulated Wire & Cable Company, has been elected chairman of the board of the U. S. Magnetic Products Corp., Chicago and Lock Haven, Pa. Manufacturing facilities are being augmented by the addition of more modern machinery for coil winding and for manufacturing electromagnets, solenoids, various types of small transformers, and magnetic specialties.

Trade Literature

Lightning Arresters.—Bulletin GEA-93H, 16 pp. Describes G-E lightning arresters for pole mounting, pellet type and compression-chamber types. General Electric Co., Schenectady, N. Y.

Lugs.—Bulletin, 10 pp. Describes a complete line of copper soldering lugs. Ilsco Copper Tube & Products, Inc., 5629 Madison Road, Cincinnati, Ohio.

Graphic Meters.—Bulletin 632, 10 pp. Describes newly designed models of a complete line of graphic meters, made in switchboard, wall, portable and other types. The Esterline-Angus Co., Indianapolis, Ind.

Transformers. Bulletin 172, 54 pp., looseleaf. Describes all types of Wagner distribution transformers. Construction features are profusely illustrated and described in detail. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.

Induction Motors.—Bulletin 111, 8 pp. Describes type AA Reliance squirrel-cage induction motors for two- and three-phase alternating current circuits, 40°C. continuous duty, open rating. Reliance Electric & Engineering Co., Ivanhoe Rd., Cleveland, Ohio.

Potentiometers.—Bulletin, 8 pp. Describes potentiometers for research, standardizing and educational laboratories. Kelvin and Wheatstone bridges and resistance boxes are part of the line. Gray Instrument Co., 64–70 W. Johnson St., Germantown, Philadelphia, Pa.

Dry Metallic Rectifiers.—Bulletin. Describes a new unit of the type "F" rectifiers, providing a reliable source of small amounts of d-c. power for the operation of sensitive electrical equipment such as relays, electromagnetic counters, industrial control devices, etc. B-L Electric Mfg. Co., 19th & Washington Ave., St. Louis, Mo.

Dust Filters.—Bulletin, 28 pp. Describes the application of air filters now installed in many industries. A chapter is included illustrating the use of such filters in connection with the air cooling of various types of electrical equipment such as turbogenerators, synchronizing condensers, frequency changers, substations, etc. American Air Filter Co., Inc., Louisville, Ky.

Cedar Pole Specifications.—Bulletin (Supplement No. 2), 24 pp. Contains the new American Standards Association specifications for both Northern White and Western Red cedar poles with other relevant information and data. Preparation of poles for butt treatment through the use of new perforating machines is described. The MacGillis & Gibbs Company, Milwaukee, Wis.

Nofuze "De-ion" Circuit Breakers.—Catalog 2246, 76 pp. Describes Nofuze load centers, panelboards, switchboards, meter services, outdoor and indoor commercial and industrial type circuit breakers, all using the "De-ion" principle of arc extinction, which enables the elimination of fuses and knife switches for circuit protection and control. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Fuse Links.—Bulletin 511, 8 pp. Describes the following types of Matthews fuse links, -bimetallic universal; fast blowing universal; open type bimetallic universal and spring type. Ampere ratings, catalog numbers, time current curves, fusing schedules indicating correct size link to use and proper method of application are discussed. W. N. Matthews Corp., 3700 Forest Park Blvd., St. Louis, Mo.

Magnetic Clutches.—Bulletin, 16 pp. Describes three types of Dings magnetic clutches—single disk, multiple disk, and serrated disk applications for special and general power transmission. A number of installation diagrams are reproduced and the method of calculating the required horsepower rating is discussed in detail. Extensive tables of performance data are also included. Dings Magnetic Separator Co., Milwaukee, Wis.

Coupling Condensers.—Bulletin 601–H, 24 pp. Describes a new development consisting of coupling condensers as a means of securing low voltage from high voltage circuits for operating instruments such as voltmeters, synchronoscopes and relays. Included is a detailed discussion of the electrical characteristics of circuits for various set-ups, with curves and wiring diagrams. Economies which are achieved are also presented. Ohio Brass Company, Mansfield, Ohio.

Motors.—Bulletin 210, 20 pp. Describes the Noel polyphase capacitor motor, which employs capacitors in a patented connection to obtain internally a power factor of unity (100%), or 80% leading, in squirrel cage and slip-ring induction motors. In addition to possessing all the advantages of the ordinary motor it is claimed that the Noel motor has a greater starting torque, a lower starting current, better efficiency, and higher speed at all loads. The Ideal Electric & Mfg. Co., Mansfield, Ohio.